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# Conference of Radiation Control Program Directors' Information for Licensing Low-Level Radioactive Waste Incinerators and Compactors

ORIGINAL

Conference of Radiation Control Program Directors, Inc.

Prepared for
U.S. Nuclear Regulatory
Commission

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# Conference of Radiation Control Program Directors' Information for Licensing Low-Level Radioactive Waste Incinerators and Compactors

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**Prepared for**
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**NRC FIN G1049**

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# ABSTRACT

This guidance was written to assist Agreement States and applicants addressing low-level waste processing as regulators or as licensees. The Low-Level Radioactive Waste Management Committee (E-5) of the Conference of Radiation Control Program Directors prepared this guidance document after evaluating current waste compaction and incineration practices with consideration of present applicable regulatory requirements for licensing. Incineration and compaction processes to reduce low-level radioactive waste volume have been licensed by Agreement States and by the U.S. Nuclear Regulatory Commission for over 20 years. Incineration volume reduction factors in the range from 10 to 100 have been achieved and compaction can reduce the waste volume by factors from 2 to 10 or more with accompanying reduction in the costs for waste disposal.

In preparation of this guidance, the focus has been on keeping radiation exposure "as low as reasonably achievable." Compaction and incineration in particular to produce a more stable waste form with enhanced performance characteristics after disposal is a positive step toward that end.

This document does not specifically address incinerator or compactor installations at nuclear power plants.

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## 1.0 PURPOSE

Transport of low level radioactive waste (LLW) by individual licensees and licensed brokers and disposal at licensed disposal sites have become a major expense for government, industry, medical and research institutions. Disposal charges, based upon the volume of waste disposed, provide a major incentive for generators to reduce the volume of LLW through (1) administrative controls, (2) waste processing, (3) storage for decay, or any combination thereof.

The Low-Level Radioactive Waste Management Committee (E-5) of the Conference of Radiation Control Program Directors has evaluated current practices and regulatory requirements for compaction and incineration in the United States. This document includes guidance based on that evaluation and various regulatory practices for licensing and compliance with a focus on keeping radiation exposure "as low as reasonably achievable".

The use of incineration and compaction to reduce LLW volume has been practiced for over 20 years. Various designs are licensed by Agreement States and the U.S. Nuclear Regulatory Commission (NRC) at numerous educational, medical, and commercial facilities. Depending upon the waste stream, incineration can accomplish volume reduction factors of 10 to 100 or more, while compaction is capable of volume reduction factors of 2 to 10 or more. In addition to reducing the cost of disposal, these volume reduction techniques (incineration in particular) can facilitate the creation of a much more stable waste form which will enhance the performance characteristics of the waste after disposal.

To maintain the proper perspective, incineration and compaction must be viewed in the hierarchy of other radioactive waste management techniques. Figures 1 and 2 provide this perspective. It is important to note that the Committee still recommends, as it did in its 1982 DOE Report, "Institutional Radioactive Waste with Restrictions for Land Burial and Environmental Methods to Manage Such Waste (DOE/LLW-ST)," that special priority be given to (1) reduction in generation, (2) segregation of waste, and (3) storage for decay, in that priority, as the most effective volume reduction techniques.

This guidance document does not specifically address incinerator or compactor installations at nuclear power plants, which are under the exclusive jurisdiction of NRC (EPA or State air quality rules would still apply). Therefore, this document was primarily written to assist Agreement States and applicants in addressing this difficult regulatory problem.

The following paragraphs summarize the intended purpose and usage of this guidance document.

1) This guidance report should be used as a resource document by regulatory agencies and applicants in evaluating the feasibility of any proposed radioactive waste incinerator or compactor.

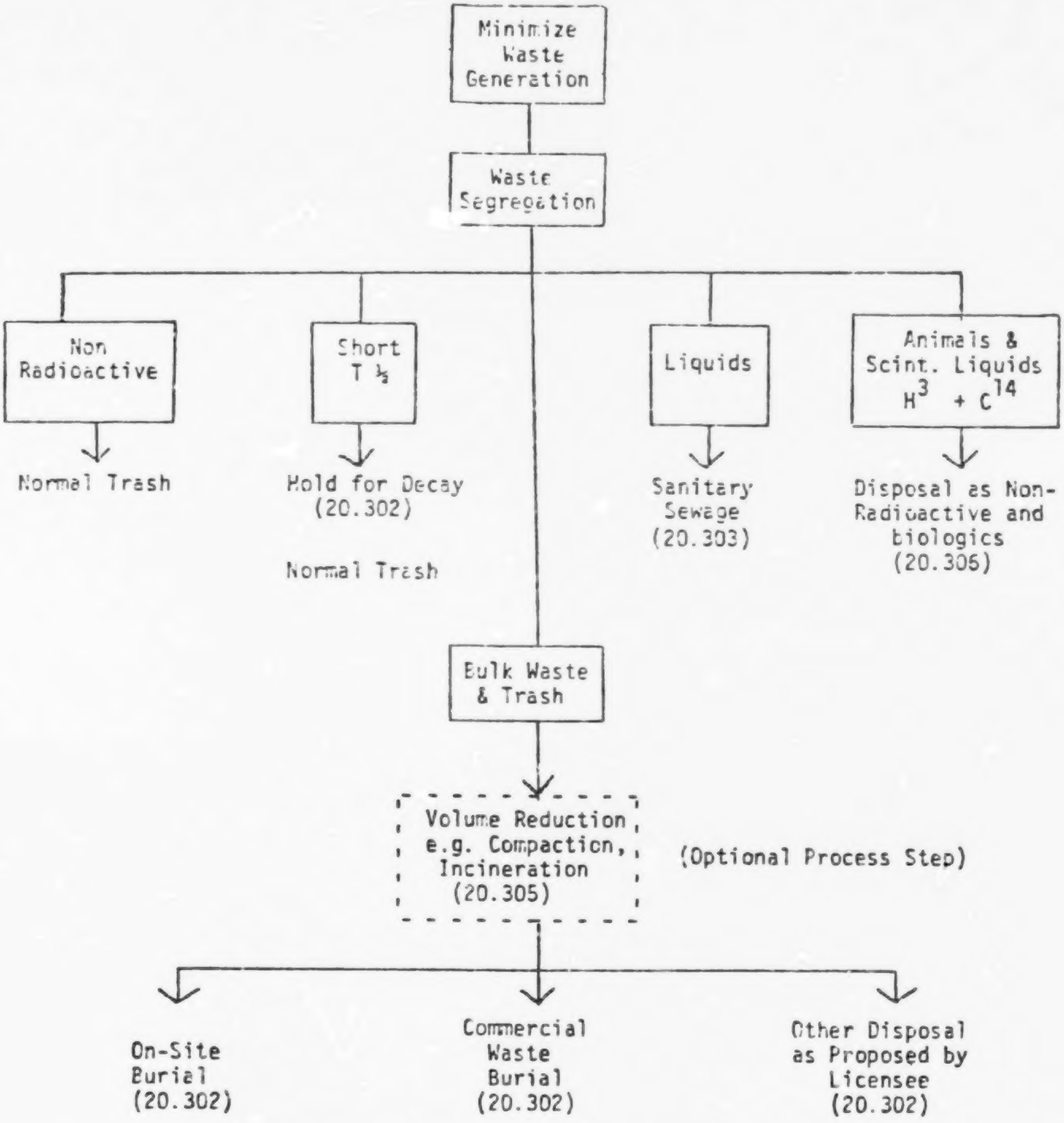
2) All of the guidance in this report should be evaluated. Applicability of these guidelines to the specific plans and operating procedures should be determined at an early stage in the planning for a proposed facility.

3) Due to the potential for changes in the state of the art of technology and in regulatory programs and regulations, this report should not be considered as the only source of guidance in the preparation and review of an application. In the final analysis, each applicant has the responsibility for determining the specific regulations that apply to their application.

FIGURE 1

FLOW CHART

PROCEDURES FOR EFFECTIVE WASTE MANAGEMENT (Reference 3)


Minimize Waste Generation
Waste Segregation
Non Radioactive
Normal Trash
Short T ½
Hold for Decay (20.302)
Normal Trash
Liquids
Sanitary Sewage (20.303)
Animals & Scint. Liquids $H^3$ + $C^{14}$
Disposal as Non-Radioactive and biologics (20.306)
Bulk Waste & Trash
Volume Reduction e.g. Compaction, Incineration (20.305)
(Optional Process Step)
On-Site Burial (20.302)
Commercial Waste Burial (20.302)
Other Disposal as Proposed by Licensee (20.302)

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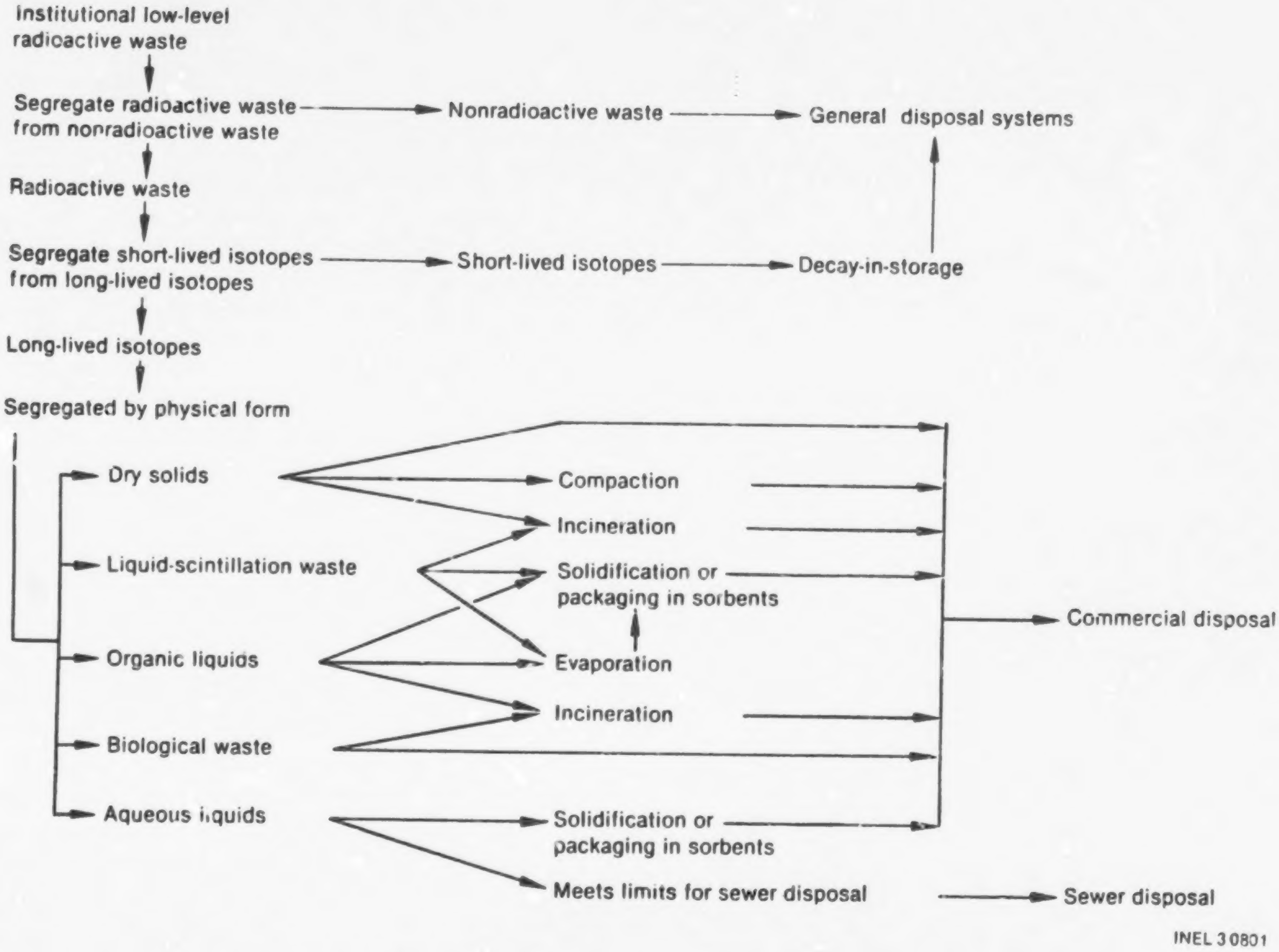
Institutional low-level radioactive waste
Segregate radioactive waste from nonradioactive waste
Nonradioactive waste
General disposal systems
Radioactive waste
Segregate short-lived isotopes from long-lived isotopes
Short-lived isotopes
Decay-in-storage
Long-lived isotopes
Segregated by physical form
Dry solids
Compaction
Incineration
Liquid-scintillation waste
Solidification or packaging in sorbents
Organic liquids
Evaporation
Incineration
Biological waste
Aqueous liquids
Solidification or packaging in sorbents
Meets limits for sewer disposal
Sewer disposal
Commercial disposal
INEL 3 0801

Figure 2. Flow diagram of practices for treating low-level waste and reducing waste volume requiring disposal. (Reference 2)

# 2.0 AVAILABLE TECHNOLOGIES

## 2.1 Incinerators

### 2.1.1 General

Any device designed to reduce waste volume by thermal oxidation may be broadly classified as an incinerator. Although a number of concepts and engineering variations have been proposed, the choice of equipment on the market for immediate use is somewhat limited. Many ideas exist only as engineering studies or "one of a kind" devices.

For the purpose of this guide, incinerators may be classified as single chamber, or multiple chamber. Other characteristics may be used to classify incinerators, such as the heating method in the primary chamber (i.e. pyrolysis, fluid bed, limited oxygen, etc.). Although these distinctions are important from an engineering point of view, licensing considerations should not be greatly dependent on them.

In all types of incinerators, the possibility of accident due to equipment failure or operator error must be considered. Plans for the care of injured contaminated persons, and for clean-up recovery from accidents should be part of the operating procedures. The depth of review should be commensurate with the risk level based on type and quantity of material to be incinerated.

### 2.1.2 Incinerator Concepts

#### 2.1.2.1 Single Chamber Incinerators

Incinerator technology developed from open burning, the classic single chamber incinerators represented an effort to enclose and confine burning. The typical hospital incinerator or "pathological destructor", is a single chamber design with several burners and forced air blowers. The advantage as compared to other concepts is low cost due to the use of simple design and readily available materials. The disadvantage is the difficulty this design has in meeting air pollutant emission limits. It appears that few of these designs will be constructed in the future, as they will largely be replaced by newer concepts.

One such concept is the suspension burning incinerators. Several designs have been proposed, all share the intent of suspending the waste in the hot gases of the primary burner for the length of time needed to complete combustion. Ash is separated by gravity, centrifugation (i.e. bending or twisting of the exhaust gas path) or filtration. Some treatment of the exhaust gases may also be required. Waste is usually fed into the incinerator continuously. Some preprocessing of the waste may be required. Both the preprocessing and the post treatment of exhaust gases must be considered by the licensing reviewer.

### 2.1.2.2. Multichamber Incinerators

The predominant concept of incineration technology in use today appears to be the multichamber, controlled air designs. These devices have the advantages of relatively simple engineering, use of readily available materials and the demonstrated ability to meet pollutant emission restrictions. Little if any waste preparation is required. Waste is usually introduced in batches, and may be contained in fiberboard boxes, plastic bags or in bulk.

Basically, the waste is introduced into the first chamber where it is burned under oxygen deficient (less than stoichiometric) conditions. This limits the temperature within the chamber, which in turn limits the production of oxides of nitrogen, but produces large amounts of carbon monoxide and hydrocarbons. The exhaust gases from the first chamber are ducted to the second chamber where additional burner(s) working with an excess of air (greater than stoichiometric) produces a higher temperature and nearly complete reduction of the CO and hydrocarbons. The final exhaust consists mainly of carbon dioxide and water vapor.

When incinerating radioactive waste, the following should be noted:

- The waste usually does not require very much in the way of preprocessing.
- The packaging and handling of waste packages should be reviewed.
- If waste is shipped from remote locations, the packaging and opening procedures for the transport containers must be reviewed.
- Essentially all volatile isotopes will escape with the exhaust gases.
- The easiest way to limit air emission may be to limit quantities incinerated.
- Extended burn times (8 hours or more) may be required for complete burndown of waste packages.
- The ash handling (cleanout and packaging procedures) should be carefully reviewed.

### 2.1.2.3 Other Technological Concepts

The moving grate designs incorporate a means to move or stir the waste during burning. This constantly exposes "fresh" surface of the waste, resulting in a reduction of burn time. The remainder of the device may be similar to either the single chamber excess air or the multi chamber controlled air devices.

Several moving grate incinerators are currently processing radioactive contaminated wastes or are being designed and built for that purpose.

The advantages are the reduced burn time compared to conventional multi chamber designs and reduced waste preprocessing compared to suspended burn designs. The disadvantage is the greater mechanical complexity of the grate mechanism. Radiation exposure during both routine maintenance and repair must be considered.

The rotary kiln designs, like the moving grate designs, seek to stir waste during burning and share the disadvantage of mechanical complexity. Problems with the seal between the rotating section and the exhaust stack section have been noted.

Fluidized bed designs use sand or some other granular or pelletized material suspended above the floor of the incinerator in a flow of air and combustion products. Waste is introduced into the bed where completion of combustion is assisted by the heated particles. The conditions of combustion are usually substoichiometric. By careful choice of bed material, volatile fractions which would otherwise escape may be captured. The bed material will be contaminated and will require disposal when expended. The reviewer should assure that an acceptable procedure for removing and packaging the bed material is included in the application. Proper operation requires a balanced flow of air. In case of equipment failure, a recovery procedure may be needed. Disadvantages include mechanical complexity, contamination of the bed material and difficulty in separating the ash.

### 2.1.3 Summary

Although the multi chamber controlled air and the single chamber suspended combustion designs seem to be the most suitable for most general applications, special conditions may favor use of another design for specific units. The license reviewer is referred to the proceedings of the Annual Symposium on Waste Management (for example Ref. 4) and the Annual Symposium on Incineration of LLRW (for example Ref. 5), and similar proceedings for information on designs not covered by this guide. Specific incinerator designs are described in more detail in Appendix A.

## 2.2 Compactors

### 2.2.1 General

Compactors may classified as low force, (i.e. compaction of waste into a container) or high force (compacts the container also). Generally, the low force compactors generate about 5,000 lbs. or less of force, while the high force devices generate 1,000 tons of force or more. Because of hydraulic considerations and possible container rupture, compaction is generally not suited for liquid wastes or wastes which contain absorbed liquids.

### 2.2.2 Low Force Compactors

Low force compactors appear most suited to small and medium sized installations where the waste stream to be handled consists of mostly dry fiberous trash. Most designs compact the waste into a final shipping and disposal container, usually a standard 55 gallon steel drum. Reduction ratios of up to 10:1 have been quoted. If the waste stream contains more dense material, ratios as small as 4:1 may result.

Most units operate vertically. The compressing mechanism is withdrawn to its maximum height and a drum is placed in the unit. Waste is loaded into the drum and a formed space above the drum, then compacted into the drum. Although the compressor provides support at the top of the drum, little support is provided to the mid and lower portions of the drum. As a result, additional shielding may need to be provided when compacting relatively hot waste material.

The reviewer must assure that the low force compactor is designed such that the operation will not damage the container and therefore fail to meet the appropriate DOT regulations.

Consideration by the reviewer must be given to the packaging, storage and transport of waste to the compactor, as well as handling and storage of partially filled and filled compacted drums. Procedures for keeping records for tracing the generation of waste in drums to be buried under Part 61 rules must be reviewed.

### 2.2.3 High Force Compactors

In addition to the higher force generated, high force compactors are generally more automated and are usually remotely operated. Although the main reason for remote operation is operator mechanical safety, the concept lends itself to the safe handling of wastes containing higher levels of radioactive materials. Since the container to be compacted is supported on all sides during compaction, it has been proposed that a careful choice of container material may allow the compaction of liquid containing wastes with no leakage. Current regulations for wastes to be disposed of ultimately by shallow land burial limit the liquid content of any waste package, however, and disposal sites may further limit liquid content. Any such proposal will thus require extensive review of the ultimate disposal of the compacted waste.

The primary containers will not be compacted to the same height, due to differences in density and quantity of contained waste. Because of the mechanism surrounding the container during compression they will be the same diameter. This facilitates loading the compressed containers into overpacks for final disposal. Most designs have temporary storage capability to allow a selection of packages to best fill the overpack.

In consideration of the mechanical complexity of the high force compactors, it may be expected that these devices will be restricted to large volume applications. One exception is the mobile high force compactor design. This device is mounted on a semi-trailer and is transported to the site of its work.

# 3.0 REGULATORY REQUIREMENTS

The purpose of this section is to (1) discuss the role of the various regulatory agencies, (2) provide general regulatory requirements for all waste management facilities, (3) discuss some specific regulatory requirements for storage for decay and disposal of deregulated waste and finally (4) discuss in detail the regulatory requirements applicable to both licensing and compliance for compactors and incinerations.

## 3.1 Applicable Agencies and Role of Each

### 3.1.1 NRC/Agreement State

Incineration and compaction of LLW must meet license requirements of the NRC in Non-Agreement States and license or permit requirements of the designated State or Municipal Agencies that operate NRC approved radiological control programs in Agreement States.

Since Agreement State regulations must be compatible with NRC regulations, the basic regulatory requirements and guidelines are established by NRC. Each Agreement State has promulgated radiation control regulations. In a few states there is more than one radiation control program based on the areas of responsibility of the State Agencies or major Municipalities within the State.

An Agreement State implements their regulations in its state. NRC implements the regulatory control of LLW in the Non-Agreement States. NRC also conducts an inspection of the State Agreement program every one or two years. The primary purpose of this NRC inspection is to determine whether the State program is compatible with NRC regulations and is adequate to protect the health and safety of the public.

### 3.1.2 U.S. Department of Transportation (DOT)

The USDOT has the broad responsibility for establishing regulations applicable to transportation of radioactive material. This is done in cooperation with USNRC. Individual containers of LLW, whether shipped with non-nuclear cargo or on a vehicle carrying only radioactive material, must meet appropriate DOT requirements. Radiation levels of individual packages and the loaded vehicle must comply with DOT regulations.

### 3.1.3 U.S. Environmental Protection Agency (EPA)

EPA has the broad responsibility for the protection of the environment. For example, 40CFR190 are the regulations that have been established for offsite exposure to radiation from uranium fuel cycle facilities. NRC regulations must also assure that applicable EPA environmental standards will be met.

The Clean Air Act provides for EPA's direct regulatory control of radionuclide emissions. The regulations which are currently applicable have been published as 40CFR61. EPA has decided that delegation of regulatory responsibility to the States shall not be automatic. Therefore States must specifically apply to EPA for delegation of the regulatory control under 40CFR61.

### 3.1.4 State and/or EPA Air Quality Programs

State Air Quality programs may have regulations that apply to the non-radiological emissions from LLW incinerators. Applicability should be determined in the early planning stages of any LLW incinerator. Section 3.3.1 addresses non-radiological air quality regulatory compliance.

### 3.1.5 State and/or EPA Solid/Hazardous Waste Programs

In some cases the residue after incineration of the LLW may contain hazardous waste materials that are not radioactive. The applicability of State and/or EPA Solid/Hazardous Waste regulations must be determined. Section 3.3.2 addresses non-radiological hazardous waste regulatory compliance.

In some cases LLW incineration may reduce the volume of radioactive waste but significantly increase the concentration of radioactivity in the residue. Regulatory control of this residue would be the responsibility of the NRC or Agreement State (Section 3.1.1). The applicant for a permit to incinerate should address the final waste acceptability by a licensed Low Level Radioactive Waste Disposal Site.

## 3.2 Regulatory Compliance - Radiological

### 3.2.1 General NRC/Agreement State Regulatory Requirements

The following general guidelines are applicable to all licensed facilities which handle or process low level radioactive waste.

#### 3.2.1.1 Required License

A radioactive materials license issued by an Agreement State or a byproduct material license issued by the U.S. Nuclear Regulatory Commission is required for any facility treating low level radioactive waste. The license would be issued in accordance with the licensing provisions of Part C of the Suggested State Regulations or 10 CFR 30.

In addition to the information normally requested of any licensee handling similar amounts of uncontaminated radioactive material (As suggested guidance see Reg. Guide 10.7 and Standard License Application for Laboratory/Industrial licenses in Appendix B), special attention must be applied to the following areas:

- Financial ability of licensee or applicant
- Special facility needs, administrative controls,
- Offsite contingency planning per the requirements of NUREG-0762
- Safety
- Indemnification requirements

### 3.2.1.2 Manifest Requirements

The timing and tracking of waste shipment manifests (shipping papers) must be accomplished pursuant to 10CFR20.311. A computer can be an indispensable tool to assist in this task.

### 3.2.1.3 Compact Requirements

The requirements of various regional compact authorities must also be complied with. Some compacts prohibit export of waste out of the compact region. Some compacts may require extensive waste treatment. Almost all compact authorities require that the waste be identified as to its original generator (the person who first decided the material was waste). They also may want to be able to track waste through processors back to the original generator. This may be a particularly difficult task when, for example, the processor is an incinerator which handles waste from many smaller generators. Requirements of the individual Compact Commissions must be consulted early in the planning stage of any alternative treatment facility.

### 3.2.1.4 Financial Assurance

Financial assets of the applicant must be sufficient to allow for both planned and unplanned events. Decontamination and decommissioning responsibilities and expenses should be determined as part of the initial licensing process. If state or federal legislation allows, a bond or other acceptable surety mechanism should be obtained to allow the orderly termination of the license after the useful lifetime of the facility. Surety mechanisms should be reviewed annually to determine if they are still in effect and remain unencumbered. Also upon license renewal, the amount of the surety should be reviewed and adjusted, if necessary, to assure that the secured amount remains a realistic assessment of the financial liability of the state or federal agency.

A surety bond or other acceptable instrument should be required to cover non-catastrophic yet unplanned occurrences. If, for example, the entire inventory of waste in storage for decay had to be disposed in a low level radioactive waste disposal site, are the assets of the company sufficient to cover that unplanned expense? Likewise, liability insurance or other surety instrument should be required to cover the financial aspects of such contingencies as fire or flood.

### 3.2.1.5 Special Facility Requirements

The facility should be in an area safe from flooding, with compatible zoning and capable emergency services. Fire and other local emergency services personnel should be contacted early in the siting process so any special training or equipment needs or requirements can be considered during the design stage. For certain types of installations consideration should be given to designs which provide for self containment with negative air pressure. The receipt of materials and traffic patterns should be such that cross-contamination is minimized.

### 3.2.1.6 Administrative Controls

Clear lines of authority and responsibility must exist for the radiation safety program. Safety personnel should have a direct reporting relationship to upper management, separate from operations personnel. This separation is necessary to preclude the possibility of operations personnel overriding or intimidating well-based judgments of safety personnel.

As a minimum, the Radiation Safety Officer (RSO) should have a Bachelors degree in a physical or other biological science and at least fours years experience in a responsible radiation protection position. Two of those years of experience should be in waste management related positions. The duties of the RSO are listed in the standard license application in Appendix B.

A sufficient number of monitors and radiological technicians should be available to complete the necessary surveys and record keeping duties. Management audits must be conducted of the safety program at least quarterly. A strong training and retraining program is also necessary. Frequencies for retraining depend on the complexity of the facility.

### 3.2.1.7 Survey Program

Routine survey requirements should be described in the license application for external radiation, contamination, and airborne monitoring of particulates and gasses. The frequency of each survey should depend on the potential for both internal and external exposure at each location.

The facility should conduct a respiratory protection program in accordance with NRC Regulatory Guide 8.15 even though facilities should be designed and constructed so as to preclude the need to routinely wear respirators. A personnel dosimetry program must consider the potential exposure to extremities, whole body, as well as internal exposure pathways. In addition to routine urine bioassays and thyroid scans, consideration should be given to whole body counting if bioassay limits are exceeded. Suggested detailed requirements for survey programs are included in Appendix B.

### 3.2.1.8 Radiation Protection Equipment

Information pertaining to the appropriateness of radiation monitoring equipment should be provided. This should include the manufacturer's name, instrument model number, the number available, the type of radiation detected, the range (i.e. mR/hr or counts/sec) the window thickness and the type of use specified for each instrument. The type of use would normally be monitoring, surveying, assaying or measuring. The reviewer should evaluate the appropriateness of each piece of equipment in light of its application and the conditions in which it is expected to operate.

In addition, details of instrument calibration procedures should be provided. This should include the frequencv, methods and procedures for the calibration of survey and monitoring instruments, as well as any other instruments and systems used in the radiation protection program, such as measuring instruments used to assay sealed source leak test samples, contamination samples and bioassay samples.

An adequate calibration of survey instruments usually cannot be performed with built-in check sources. Electronic calibrations that do not involve a source of radiation are also not adequate to determine the proper functioning and response of all components of an instrument.

Daily or other frequent checks of survey instruments should be supplemented with a two point calibration on each scale of each instrument with the two points separated by at least 50 percent of the scale. Survey instruments must also be calibrated following repair. A survey instrument may be considered properly calibrated when the instrument readings are within 10 percent of the calculated or known values for each point checked. Readings within 20 percent are considered acceptable if a calibration chart or graph is prepared and attached to the instrument.

If the applicant proposes to calibrate his instruments, a detailed description of planned calibration procedures should be submitted. The description of calibrations should include as a minimum:

1) The manufacturer and model number of the source(s) to be used

2) The nuclide and quantity of radioactive material contained in the source

3) The activity of the source(s) and the traceabilility of the source to a primary standard (N.B.S.)

4) The step by step procedures for calibration, associated radiation safety procedures, and

5) The name(s) and pertinent experience of person(s) who will perform the calibration.

If the applicant intends to contract for the calibration of instruments, the name, address, and license number of the calibration firm must be specified together with the frequency of calibration. The applicant should contact the firm that will perform the calibrations to determine if information concerning calibration procedures has been filed with the Commission or Agreement State. If information has not been filed, information concerning calibration procedures should be obtained and submitted.

Instruments used to evaluate samples for contamination control such as those used to analyze air samples, filters, and to perform surveys of personnel, work areas and equipment must be calibrated. The procedure(s) and frequency for calibration of such instruments should be submitted and should include:

1) The name(s) of the supplier of the standard(s) to be used

2) The nuclide and quantity of radioactive material in the standard source(s)

3) The accuracy of the source(s) (As a minimum 5% of the stated value and traceable to a primary standard such as that maintained by the National Bureau of Standards)

4) The name(s) and pertinent experience of person(s) who will perform the instrument calibrations.

5) The frequency of calibration, which must be consistent with the use, stability and importance of the device in the radiation safety evaluation.

Personnel monitoring equipment must also be appropriate for the radiation type, intensity and operating conditions likely to be encountered by incinerator personnel. The description of personnel monitoring equipment should include the type (film badges, TLD, pocket dosimeters) to be used, the frequency of evaluation, and the purpose for which the devices are used (whole body or extremity). A description of methods of calibrating and processing monitoring equipment or specification of the type of services to be obtained from commercial suppliers should be submitted. See Appendix B for additional suggested requirements and sample forms for instrument calibrations.

### 3.2.1.9 Environmental Exposure

A pathway analysis must be provided which calculates doses expected to the nearest resident(s) affected by the operations of the facility. The source term should be related to the release levels from the facility. Because survey equipment may be limited in its sensitivity, a combination of surveys and administrative controls may need to be imposed for some radionuclides (such as I-125) handled or processed by the facility. An environmental monitoring program should also be established. It should focus not only around the facility, but also around any areas where the decayed or radioactive materials have been disposed. In this way the environmental monitoring program will verify the pathway assessment and confirm whether release limits have been achieved. A pre-operational program must be conducted to establish base line conditions. An environmental TLD program should be an integral part of the environmental monitoring program. For additional suggestions for an adequate environmental monitoring program Reference 6 should be consulted.

### 3.2.1.10 Contingency Planning

When deemed necessary, emergency response plans should be formulated per the requirements of NUREG-0762, "Standard Format and Content for Radiological Contingency Plans for Fuel Cycle and Materials Facilities." Although the format of that document is more easily applied to processing facilities than waste storage facilities, the concepts are still applicable once the source term is established. The need for emergency response plans should be made on a case by case basis and should be based on (1) quantity of radioactive material stored or processed, (2) physical/chemical form of the material, (3) accident possibilities, and (4) facility siting.

### 3.2.1.11 Outside Concerns

The fire department having jurisdiction must be identified. The applicant must show that his fire department is capable and knowledgeable to handle a facility fire. Additional training may be necessary. Consideration should be given to requiring formal letters of agreement. Licensees should be required to coordinate with the fire department and provide it with floor plans of facility that indicate what is stored in each area and phone number of licensee representative in case of emergencies.

The local disposal authority must be consulted early in the process if any treated or stored materials are to go to a landfill to determine what, if any, additional information will be necessary. State or federal environmental protection requirements may require the submittal of an environmental impact statement or submittal of an environmental checklist, depending on the nature of the facility and local requirements. These requirements may involve the need for public hearings or some additional public involvement.

### 3.2.2 Specific Licensing Requirements

### 3.2.2.1. Segregation and Storage for Decay

### 3.2.2.1.1 Facility Requirements

In addition to the general requirements noted in Section 3.2.1, the following special requirements should be considered for facilities designed to utilize storage for decay.

- Sumps should be provided to collect and contain liquids from the waste itself and personnel or facility decontamination operations.

- Any collected liquids must be retained for sampling and treatment, if necessary.

- Temperature and humidity controls should be considered if packages are to be stored for more than six months.

- The facility should rely on engineering controls and air sampling and analysis, rather than individual respirators, as the primary means of controlling air particulates during any sorting operation.

- Facility layout should limit external radiation exposure to both personnel and environment.

- Traffic patterns within the facility should limit the potential for cross contamination.

It is suggested that NUREG/CR-4062, "Extended Storage of Low-Level Radioactive Waste: Potential Problem Areas", be reviewed to identify other potential problems prior to facility design and/or approval.

### 3.2.2.1.2 Waste Acceptance

Receipt inspection of waste packages must be performed to verify that the waste is appropriate for management by a storage for decay facility. A facility licensed to store for decay must have detailed knowledge of the generators who use the facility's services. Generators who are authorized to use only short half-life materials may need less verification of waste contents than do generators of both long and short half-life materials. The chemical compatibility of the waste with the waste package must also be considered in determining whether to accept the waste at the facility. Segregation of wastes by half-life within the facility can assist in reducing unnecessary or redundant surveys and handling. Once waste is accepted at the facility specific waste inventory records must be maintained to identify the location of each package, its contents (activity, chemical form, type of waste, solidification or sorbent media used, type of package, and information on any hazardous constituents which may remain after the radioactivity has decayed), package volume, generator of the waste and license number, as well as any other applicable permit number. Bar coding of packages and computer tracking of the waste within the facility can greatly assist this process.

### 3.2.2.1.3 Survey Program

Special attention must be placed on surveying the waste prior to its release to unrestricted areas. Prior to release every package must be sorted and surveyed in detail to determine if the waste has, in fact, decayed to background levels. This must be performed with instrumentation sensitive to the energies and radiation types both expected and unexpected from the waste, e.g., scintillation probe, thin window geiger-meuller, an alpha probe, and follow up wipe samples of likely hot spots. The levels measured must be indistinguishable from background levels or below license release limits. It is anticipated that federal guidance on what is below regulatory concern will be forthcoming. Once that exposure level is set, facility release limits may be adjusted accordingly.

Measurements must be sensitive enough to provide meaningful results. The sensitivity must be related to a pathway analysis to verify that materials released from the facility will result in acceptably low doses to the general public. In addition to measurements, calculations can assist in determining that materials have decayed to acceptable levels.

Inner and outer containers must have any radioactive marking either removed or totally obscured prior to disposal as non-radioactive waste.

### 3.2.2.2 Disposal of Deregulated Wastes

The disposal of certain wastes has been deregulated with regard to their radioactivity only. Wastes in this category include at the present time animal carcasses containing concentrations of C-14 and/or H-3 less than or equal to 0.05 microcuries per gram of animal tissue and scintillation vial wastes containing concentrations of C-14 and/or H-3 not to exceed 0.05 microcuries per gram of scintillation media. The disposal of these wastes is subject to the provisions of 10CFR20.306 or equivalent state regulations. The regulations do not exempt this waste from any other regulations, merely from the radiation control regulations relating to disposal. Hazardous wastes must be disposed taking into consideration the wastes' toxic characteristics. An example is some scintillation vial waste which contains toluene or xylene.

### 3.2.2.2.1 Scintillation Wastes

Generators may dispose of scintillation liquids by transferring them to a hazardous waste broker or by sending directly to a treatment facility. Ultimate disposal may include the utilization of the flammable liquid as a fuel additive in a kiln or furnace. The requirements of the Resource Conservation and Recovery Act (RCRA) must also be met for this type of disposal. Thus the waste generator must register as a RCRA generator and the waste must be manifested as hazardous waste, unless they are exempted by the small quantity rule. Generators of scintillation vial wastes have been able to greatly reduce their cost for disposal of scintillation liquids by using this technique over shallow land burial. The vials which are left behind can be disposed as low level radioactive waste or can be rinsed and disposed as non-radioactive waste. Another technique to reduce waste volume is to recycle scintillation liquids via a distillation technique. This method is of value when the scintillation counter is used for only relative count rates. The capital outlay for the distillation equipment is offset by the lower consumption rate for the scintillation cocktail. Disposal would ultimately be by incineration.

### 3.2.2.2.2 Animal Carcasses

The disposal of deregulated animal carcasses can be conducted in the same manner as disposal of non radioactive experimental animals. Many large institutions already have a biological incinerator for this purpose. Incineration in accordance with local air quality requirements is generally the most viable disposal option.

### 3.2.3 Compaction

Compaction of low-level radioactive waste can be an effective method for waste volume reduction when used alone or in conjunction with other practices such as storage for decay, incineration, liquid disposal to the sewer and below regulatory concern disposal.

#### 3.2.3.1 Information Required on an Application

The following sub-sections address information that should be submitted in a license application for authorization to use compaction as a waste reduction procedure.

Section 3.2.1. should also be referred to for further discussion of some of these issues or additional items that need to be addressed in a license application.

##### 3.2.3.1.1 Personnel Qualifications and Training

The license applicant should identify the facility administration including the supervisory personnel for occupational radiation workers. The information should include personnel names and job title and job description for corporate officers and supervisory personnel. Job categories may be used for non-supervisory personnel.

Training and experience for personnel, particularly supervisory personnel and radiation workers, should include formal and on-the-job training and experience relative to the individual's waste compaction activities.

The applicant should also describe any in-house training procedures including submitting an example examination with correct answers, training course outlines, and any continuing education or in-service refresher training that employees participate in.

### 3.2.3.1.2 Waste Compaction Procedures

The applicant should submit a summary narrative to describe the waste compaction procedures. The summary narrative should help the reviewer to understand the overall process. A procedures manual or other submitted information can be used to explain the processes and address specific topics required by the licensing agency or other requirements such as regional waste site packaging requirements or transportation requirements for a particular waste form.

The narrative should include:

- Waste generation or waste receipt verification
- Complete compaction procedures including process quality control, (ie, waste inventory verification after the process)
- Radiation safety procedures for personnel including notification procedures.

- Waste sorting procedures (should include remote handling techniques if appropriate, liquid waste control, etc.)
- Emergency procedures (should include corrective actions in the event of or continuation of internal/external contamination of personnel or environmental release of radioactive material, notification of authorities, duties of personnel, etc.)
- Record keeping procedures for all receipt, sorting and packaging processes and other processes where record keeping should occur or is required by the licensing agency.

### 3.2.3.1.3 Radiation Safety

In addition, the following topics should be specifically addressed as part of a radiation safety plan.

a. bioassays  
b. whole body scan (if any bioassay indicates that limits have been exceeded)  
c. personnel monitoring  
d. area radiation surveys  
e. contamination surveys - routine  
f. meter calibration procedures  
g. leak test procedures

h. respiratory protection program
    1. breathing zone air samples
    2. respirator fitting and testing program
    3. maintenance program for equipment
i. facility security
j. protective clothing

### 3.2.3.1.4 Compacted Waste

The products of the compaction process should be described. The information should include quality assurance testing procedures for the final compacted and packaged product. Package leak testing and labeling should be addressed when packages will be moved or transported from the compaction facility. Physical or chemical characteristics should also be fully described to ensure other hazardous waste requirements are met.

### 3.2.3.1.5 Facility Design Considerations

The applicant should submit the following details concerning facility design:

- Floor plan and specifications for office and compaction process facilities.

- Ventilation systems should be described where appropriate-including test and replacement procedures for filter systems and emergency procedures in the event of system breakdown.

- Details of construction and operation of special systems such as hot cells, glove boxes and retention tanks for liquid waste from compaction. Ventilation and plumbing specifications for these special systems should be included.
- Laundry facilities or contracted laundry services
- Traffic patterns of personnel and radioactive waste in the facility.
- Fire detection and suppression systems and storage building specifications which include curbing to prevent offsite release.
- Access controls to restricted areas
- Identification of unrestricted areas such as restrooms and eating facilities.

### 3.2.3.1.6 Environmental Monitoring

In conjunction with the personnel monitoring and periodic bioassay program described above, consideration should be given to the requirement for environmental monitoring program if the waste handling or compaction processes may result in possible releases to the environment.

The applicant should submit procedures and sampling frequency for air, water, soil and vegetation, if appropriate. The procedures must include action levels based on applicable state requirements and methods to be used for sample analysis. The types of monitoring, sample techniques and result records should be described.

### 3.2.3.2 Compliance Guidelines

The review of a license application including waste compaction procedures should include the following additional considerations which are specific to the compaction process;

- A review of waste sorting procedures should be conducted to ensure removal of sealed sources, long-lived materials or waste material not compatible with the process to be used.

- Consideration for volume of waste to be compacted with respect to ultimate disposal method, volume, retention time before further processing, container size, etc.

- Large thick walled metal containers may endure compaction pressures better than 55-gallon drum containers. Some containers may not meet transportation requirements after being used in the compaction process.

- In addition to transportation requirements, containers may also need to meet special disposal site conditions.

- Certain non-radiological safety concerns must be considered in the review process. Glass shredding (liquid scintillation vials, etc.) should be done with precautions to eliminate fire hazards by using non-spark shredder blades and other fire prevention techniques such as adequate wiring for electrical components to prevent sparking and sufficient ventilation of solvent fumes.

- Additional solidification procedures will be necessary in the compaction process if liquid waste is generated as a byproduct.

- A review should be conducted to ensure that accurate calculations based on conservative assumptions indicate environmental release limits in federal or state regulations are not exceeded.

- Radiological occupational safety should be stressed. Whole body, extremity and bioassay monitoring should be described or explanation and calculation offered if monitoring is not to be performed.

- Narrative and schematic descriptions should be submitted to explain the compaction procedures of the waste handling process. The procedures should include waste receipt, sorting, compaction, and waste packaging.

- A careful review should be conducted to verify that handling and packaging procedures are compatible with ultimate disposal for compacted waste.

- Non radiological occupational safety (i.e. sampling for Toluene).

### 3.2.4 Incinerator Regulatory Requirements

#### 3.2.4.1 Information Required to be Submitted

Since each state regulatory structure is somewhat unique, it is difficult to address the regulatory requirements for incineration of LLW without a familiarity with the complete specific administrative mechanisms which will be utilized in its regulation.

As indicated in Section 3.1, it is readily apparent that several agencies could be involved in the licensing/approval process for the incineration of LLW. These agencies might include the EPA, NRC, state radiological and air quality agencies and in some instances the DOT. Fundamental to the regulatory process is the method by which applications for the incineration of LLW are processed through these various agencies. Essentially they can either be processed sequentially through the involved agencies or concurrently. Furthermore, the applicant may submit either a single application containing all the information required for every agency's review or multiple applications which contain only the specific and sometimes overlapping information required for each agency's review.

As such, the above considerations markedly affect the scope of informational requirements which any one application format must address.

This complex and somewhat overlapping regulatory structure may create additional problems for both the applicant and affected regulatory agencies in processing and reviewing an application.

In light of this, a list of the questions which might be asked of an applicant by transportation, radiation control and air quality agencies has been compiled.

It is not expected that every applicant address each of the following. It is assumed that each application will be unique and that each must be considered accordingly. As such, a useful application format might allow flexibility in which the applicant could address only the pertinent items. A sample application is included in Appendix C.

Section 3.2.1 should be referred to for further discussion of some of these items or additional issues that may need to be addressed on an incinerator application.

### 3.2.4.1.1 Materials and Isotopes Subject to Disposal

Sufficient data pertaining to the material to be incinerated should be elicited to determine the suitability of incineration as a volume reduction/disposal method. Required information should provide estimates of the expected volume reduction and the isotope concentrations expected in ash and effluent. Such estimates when compared with actual results could provide a measure of process efficiency and normal operating parameters.

Suggested informational requirements should include:

- Isotopes and Mass Number
- Curies to be Incinerated/Year and Burns/Year
- Curies to be Incinerated per Incinerator Charge
- Composition of Tagging Material
- Composition of non-radiological debris
- Waste Specifications (As required or pertinent)
    1. Melting Point
    2. Vaporization Point
    3. Oxidation By-Products
    4. Explosive Potential of Material or Matrix
    5. Specific Activity
    6. Flammability
    7. Physical Form (Solid, Liquid, Gas or Slurry)
- Expected Isotope Concentration in Ash and Effluent
- Expected Ash Volume

### 3.2.4.1.2 Incinerator and Stack Specifications

This area in combination with the previous section provides information relevant both to radiation control and air quality. Three areas of interest are identified, each representing engineering and operating considerations.

- Incinerator Specifications
  1. Manufacturer
  2. Identification (Model Number)
  3. Rated Capability in lb./hr.
  4. Recommended Charging Volume
  5. Recommended Charging Methods
     a. Capacity in B.T. U./hr.
  6. Secondary Burner Fuel
     a. Capacity in B.T.U./hr.
  7. Recommended Frequency and Method of Ash Removal
  8. Maintenance Specifications
- Stack Specifications
  1. Stack Height
  2. Stack Diameter
  3. Temperature at Outlet
  4. Flue Gas Velocity

- Off Gas Treatment
  1. Method
     a. H.E.P.A. Filtration
     b. Bag Filtrations
     c. Electrostatic Precipitation
     d. Scrubbers (Wet and Dry)
     e. Handling and Disposition of Filtrate/Filters
     f. Maintenance Specification for Treatment Systems
  2. Expected Source Term Range
- Related SPECIFICATIONS
  1. Location Demographics
  2. Drawings of Facility and Adjacent Uncontrolled Areas
  3. Location Topography
  4. Meteorologic Considerations
  5. Description of Potential Pathways

### 3.2.4.1.3 Pre-Incineration Packaging and Handling

Information pertinent to pre-incineration packaging and handling should address those factors which involve personnel safety and potential for contamination. Materials which could become airborne or would require shredding or sub packaging could indicate the need for specialized air handling equipment or protective apparel. The potential diversity of methods involved in this section preclude specificity.

Information pertaining to packaging and handling should include:

- Storage prior to Incineration
- Reduction of LLW to Incinerator Batch Charge
- Description of containers (If Incinerated)
- Methods of Containment Control (Dust and Spillage)
- Description of Incinerator Charging Method

### 3.2.4.1.4 Emergency and Decontamination Procedures

In addition to the normal operating procedures requested for routine operations, information which demonstrates the user's ability to address contingency operations and conditions should be reviewed.

- Method of Incinerator/Facility Decontamination
    1. Conditions at which decontamination is required
    2. Decontamination limits for both restricted and unrestricted areas
- Procedures for the removal of incomplete burns
- Procedures in Emergency Situations
    1. Personnel Injury
    2. Equipment Breakdown
    3. Burn Interruption
    4. Fire
    5. Flood

- Procedures for communication with Fire/Safety/Regulatory agencies
- Procedures for Personnel Decontamination

### 3.2.4.1.5 Personnel Monitoring and Training

Information to ensure the training of personnel in regards to safety, emergency procedures incineration, and monitoring operations could also be considered.

- Description of the training required/possessed by incinerator operators
- Description of the training required/possessed by individuals
- Methods for personnel dosimetry
  1. Personal Monitoring
  2. Bioassay

### 3.2.4.1.6 Ash and Effluent Specifications

The assurance of regulatory compliance would require information pertaining to the actual quantity and activity of ash and effluents be provided. Methods and frequency of monitoring in addition to the ultimate disposition of ash is essential to the evaluation of the total incineration process.

- Ash and Effluent Specifications
    1. Methods for the evaluation of effluent isotope concentration and dispersal
    2. Method for the evaluation of ash activity
    3. Procedures and frequency of ash removal and packaging
    4. Procedures for the transportation of ash
    5. Disposition of ash

### 3.2.4.2 Incinerator Compliance Guidelines

#### 3.2.4.2.1 Applicant

Regulations generally require that no person shall dispose of radioactive waste by incineration except as authorized by a specific license or as authorized by 10 CFR 20.306 or equivalent Agreement State rules.

#### 3.2.4.2.2 Location of the Incinerator Facility

The location of the incinerator should be clearly identified. A street address is adequate identification. A Post Office box or similar designation is not acceptable. The lack of a clear and specific location is a deficiency.

### 3.2.4.2.3 Radiation Safety Officer

The identity of the radiation safety officer (RSO) should be clearly established. This individual is responsible for the safe conduct of incinerator operations and compliance with regulatory requirements. This individual must be qualified by training and experience to use the materials and incineration processes in a manner that protects health and minimizes danger to life and property.

### 3.2.4.2.4 Qualifications of the Radiation Safety Officer, Operations Officers and Incinerator Personnel

The qualification required by each position will vary contingent upon the administrative structure of the operation.

The RSO should have the responsibility to ensure that the radiation protection program is carried out. This responsibility should be formally delegated in writing by responsible management and should include authority for the RSO to communicate directly with the level of management that can take corrective action when needed to enforce rules and procedures pertaining to the institutions radiation safety program. Administrative authority to suspend certain activities temporarily should be provided to the RSO when needed in emergencies to avoid immediate danger to life or health. Designation of an RSO by the appropriate level of management must be included in licensing documentation.

The applicant should provide a resume of the training and experience in the use of radionuclides and radiation for each person in the applicant's organization who will directly supervise the operations or who will have radiologic safety responsibilities. The resume should include a description of training, both on the job and formal course work. In addition, the location where the training was received and the duration should be documented and submitted. Training should cover knowledge of:

1) Principles and practices of radiation protection
2) Radioactivity measurements, standardization, monitoring techniques and instruments
3) Mathematics and calculations basic to the use and measurement of radioactivity
4) Biologic effects of radiation.

In addition, a summary of the actual use of radioactive materials specifying the isotopes handled, the maximum experience and the type of use should be submitted. Minimum qualification for each of the specified individuals will vary dependent upon the scope of the operation. Regardless of the scope, the minimum qualification should include either formal course work in the aforementioned topics, certification in Health Physics, or equivalent training and experience.

Incinerator operators should have formal training or on the job radiation protection training under the direct supervision of the RSO or a course described in the application and approved by the Department.

This training should include but not be limited to:

1) Information concerning the storage, transfer, or processing of radioactive material or of radiation in the controlled area;

2) Instruction in the health protection problems associated with exposure to radioactive material or radiation, precautions or procedures to minimize exposure, and in the purposes and functions of protective devices employed;

3) Instruction in, and instruction to observe, to the extent within the workers control, the provisions of these regulations and of any license which concerns the protection of personnel from exposures to radiation or radioactive material;

4) Information pertaining to their responsibility to report promptly to the licensee's RSO any condition which has caused or may cause a violation of regulations, condition of the license, or which has caused or may cause unnecessary exposure to radiation or radioactive material;

5) Instruction in the appropriate response to warnings made in the event of any unusual occurrence or malfunction that may involve exposure to radiation or radioactive material; and

6) Information regarding the radiation exposure reports which workers may request.

### 3.2.4.2.5 Incinerator, Isotope and Stack Specifications

While the diversity of incinerator and stack designs precludes specific guidelines, suitable incinerators would probably be multi-chambered with input air control capability with a variety of fuels utilized. Sufficient chamber temperatures to achieve complete combustion should be demonstrated. Stacks should be located and incinerator operated to ensure release concentrations are at or below the limits for unrestricted areas as specified in 10 CFR Part 20. The operations should comply with "as low as reasonably achievable" (ALARA) guidelines discussed later is this section. Stack height should comply with U.S.E.P.A. stack height regulations as specified in 40 CFR Part 51. In general the suitability of a particular incinerator must be evaluated on an individual basis.

The suitability of incineration of low level waste requires evaluation of the compatibility of the isotopes and debris to be incinerated with the incinerator and stack specifications. The characteristics of the waste to be incinerated must be reviewed to determine the suitability of the isotope and the associated waste for incineration. The melting point, explosive potential, flammability and oxidation byproducts of the incinerated waste should be reviewed from both a radiological and non radiologic standpoint. In addition to 10 CFR 20 standards, various other regulatory standards apply to incineration, especially as directed towards emissions of NO, SO, CO, hydrocarbons and particulates. The reviewer must be aware that although incineration of a particular isotope could pose little problem, incineration of the tagged agents or associated debris might render the process unsuitable.

The suitability of the incinerator to handle the particular form of waste should be ascertained. Incinerator manufacturers specifications for handling liquid waste are of particular importance. In addition, charging methods and rates should be reviewed to insure that incinerator specifications are met and to aid in the determination of the estimated activity per charge or unit time to be incinerated.

Flue gas velocity in conjunction with stack outlet diameter should be utilized to provide an estimate of the air flow through the system. The data provided should be sufficient to determine the activity in the flue gas. It is a conservative estimate to assume that 100% of the isotopes incinerated are exhausted with the flue gas. If the calculation demonstrates that the activity of the flue gas outlet when averaged over a one year period is less than or equal to 10% of the limit established in 10 CFR Part 20 for an unrestricted area (Appendix B, Table II), further detailed pathway analysis is not warranted. This is consistent with an NRC staff position on information required for approval of treatment by incineration dated October 3, 1979. If the facility establishes controlled areas at points beyond the stack exhaust, more extensive modeling should be required to demonstrate that concentrations at controlled area boundaries do not exceed 10 CFR Part 20. ALARA considerations dictate that annual average offsite concentrations should be a small fraction of 10CFR20 Appendix B, Table II, or not exceed these limits when averaged over any twenty four (24) hour period. In the same context, calculations based on the assumption that 100% of the incinerated isotopes are contained in the ash, will allow for a conservative evaluation of ash handling, transportation and disposal.

### 3.2.4.2.6 Stack Emission Treatment

Stack emission treatment requires the reviewer's careful assessment. The emission treatment can be directed towards either non-radiological or radiologic emission components. Even if the primary purpose of stack emission treatment is to modify non-radiological effluent components, it may impact upon those of radiologic concern. The use of filtration or scrubbing agents can result in the concentration of radioactive materials in elements of those systems, or at least the rerouting of radioactive material through the waste stream. The reviewer must be careful to insure that mechanisms exist to control these additional waste streams. The appropriateness of the treatment systems for the types of isotopes being incinerated should be carefully studied. Information relevant to the disposition of radioactive substances in filters, electrostatic scrubbers or in scrubbing water must be submitted, in addition to procedures pertinent to the maintenance of the systems and the ultimate transportation and disposition of any low level waste generated by those systems. The regulatory considerations which pertain to other aspects of the operation will also apply to the emission control systems. The methods of monitoring, personnel safety, transportation and disposal should all be reviewed to insure compliance with applicable regulations.

### 3.2.4.2.7 Packaging and Handling

Review of the handling and packaging aspects of incineration should be directed towards the assurance that throughout the incineration process, contamination is minimized and procedures and techniques are established to insure personnel protection. The flow of low level waste through the system should include the opening of packages and containers, compaction, shredding, storage and sorting. In each process the reviewer must consider the technical soundness of the methods employed, monitoring, the possibility of contamination, emergency procedures and the methods used to ensure that personnel exposure is kept as low as reasonably achievable. As in previous sections, maximum permissible exposures for personnel, area exposure levels, airborne contamination levels, postings, contamination limits and monitoring equipment and procedures should be reviewed for applicable regulatory compliance.

### 3.2.4.2.8 Bioassay

Routine bioassay is required when personnel handle uncontained, unsealed millicurie quantities of radioactive material or when air sampling is required for the purpose of occupational exposure control.

The necessity for bioassay measurements may also be indicated following an incident such as a fire, spill, equipment malfunction detection of airborne contamination above a set limit, or other departure from normal operations which caused or could have caused abnormally large concentrations of airborne radioactive contamination.

The bioassay program should include capabilities for excreta analysis and in vivo measurements, made at a sufficiently high frequency to ensure that engineered confinement of air and surface contamination control is adequate for employee protection. The program should include all occupationally exposed employees. In addition, at least one non-radiological exposed worker should be included as a control.

Bioassay action levels, at which corrective measures are to be taken, should be established and clearly stated.

#### 3.2.4.2.9 Documentational Requirements

The reviewer should ensure that the following additional procedures are submitted, reviewed and made part of the licensing documentation:

1) Incinerator Decontamination
2) Personnel Decontamination
3) Emergency Procedures
4) Personnel Monitoring
5) Facility Survey
6) Personnel Training
7) Operating Procedures
8) A.L.A.R.A. Plan
9) Evidence that all government agencies having jurisdiction have been notified of radioactive waste incineration plans and have no objection.

### 3.2.4.3 Additional Considerations for Large Regional Incinerators

Large regional incinerators which will be accepting waste from outside the licensee's immediate control present some special regulatory problems that need to be further addressed. These problems are primarily related to the larger potential throughput and the maintenance of adequate quality assurance on the characteristics of the incoming waste.

Since a licensee for a regional incinerator will be accepting waste from various generators/brokers, it will be necessary to rely on the manifest information submitted with the waste when applying the necessary license or administrative controls. From a radiological control standpoint, this is a particularly difficult problem for waste streams containing C-14, tritium or other non-penetrating radiation which cannot be easily verified by non-intrusive measurements. Since most of the C-14 and tritium will be released to the environment during the incineration process, these isotopes will usually dominate the offsite dose assessment. It is recommended that some means be used to verify that waste, which has been incorrectly characterized, does not contain a large quantity of these isotopes that could be inadvertently released. To address this problem, consideration should be given to the installation of a real time, continuous monitor in the effluent stream. It is recognized that currently available low energy beta monitors would not have sufficient sensitivity to detect normally expected concentrations. Continuous monitoring instruments are available with sensitivities which could detect gross discrepancies in expected release, and could therefore act as a safety device to initiate appropriate action. Continuous sampling for these critical isotopes is also recommended with counting on a frequent basis to assure compliance and assure detection of unexpected releases.

Another related problem involves the need for separating non-incinerable items that could interfere with the operation of the incinerator prior to charging. This could be accomplished by X-ray examination of each package. Manual sorting could also be used, but is less desirable due to the occupational exposure considerations.

Consideration must also be given as to whether the incinerator will be accepting waste from outside the compact region. If it will be, additional operational constraints and waste handling considerations will need to be addressed.

Finally, because of the larger throughput and the extent of waste receipt, a regional incinerator will likely create a much greater public awareness which will undoubtedly result in increased local opposition. Therefore an increased opportunity for public involvement in the regulatory process should be made available.

## 3.3 Regulatory Compliance (Non-radiological)

### 3.3.1 Air Releases

As noted in paragraph 3.1.4 State Air Quality programs and/or EPA have regulations that apply to the non-radioactive emissions. Since the regulations that apply will vary from State to State, the applicant should determine with the cognizant State and/or EPA program whether there are regulations for the predicted quantity and concentrations of the non-radioactive emissions from the incinerator. In addition, depending upon the type of material (non-radiological hazard index) and the quantity, the facility may have to obtain a RCRA Part B permit as a hazardous waste treatment facility.

### 3.3.2 Solid Waste Disposal

As noted in paragraph 3.1.5 State or EPA Solid/Hazardous Waste regulations may apply to the incinerator residues. Since the regulations will vary from State to State, the applicant should determine with the cognizant State and/or EPA program whether there are regulations for the disposal of incinerator residues.

The applicant should confirm with the State or EPA Solid/Hazardous Waste program that the incinerator residues with hazardous wastes other than radioactive wastes may be accepted at one or more disposal facilities operating under a State or EPA Solid or Hazardous Waste permit. The applicant for the incineration permit then has the responsibility for obtaining approval from such a facility for disposal of the residue from the LLW incinerator.

## 3.4 Local Government/Public Interaction

It is recognized that the Local Government and public concern for even small quantities or concentrations will be a factor in obtaining the required license or permits for incineration of radioactive material. An environmental report should be included with the application. This will assist in providing the information that Local Government and the public will need to evaluate the proposed incinerator. Opportunities for public information meetings or hearings should also be made available. State and Federal rules may require notification of local authorities and/or the public of permit proceedings.

## 3.5 Recommendations

The following are the major recommendations of this report:

1) Incineration and compaction appear to be effective processes for volume reduction of LLW. However, they should be used only in conjunction with an overall waste management plan which stresses reduction in generation, segregation and storage for decay as the most effective volume reduction techniques.

2) Incineration should be given additional regulatory oversight due to potential for increased occupational exposure and environmental impact from radiological and non-radiological releases.

3) All involved permitting agencies should be identified early in the regulatory process so that permitting actions can be coordinated and satisfied. It should be recognized that for incinerators differing regulatory requirements by various responsible State and/or Federal agencies may create problems in obtaining and coordinating permits/licenses.

4) Large regional incinerators will be more difficult to license and regulate due to larger throughput, increased need for quality assurance of incoming waste and increased public concerns. Opportunities for public input and participation in the regulatory process should be made available.

5) It is very important that the licensee have a program to ensure that the incinerator ash is handled properly and meets the regulatory requirements of both 10CFR61 and the disposal site.

6) Ensuring the quality and completeness of the licensee's radiation safety program is probably the single most important aspect of the license review process. This particularly includes the qualifications and training of the radiation safety officer since the execution of this safety program is his direct responsibility. Clear lines of authority and responsibility must be identified and upper management should have some involvement in this program.

7) The characteristics of the waste must be thoroughly reviewed to determine that it is compatible with the design of the incinerator. This includes the need for a quality control program to verify that the waste is as indicated on the manifest. This is particularly important for waste received from outside the licensee's immediate control.

8) A license application for incineration or compaction should include an assessment of maximum doses to individuals in the general public based on a realistic pathways analysis. This analysis should demonstrate that unrestricted public exposures will be maintained as low as reasonably achievable.

9) It should be verified early in the process that all non regulatory government agencies that have interest in the incinerator application have been notified.

10) For incinerator installations that have large projected releases of C-14, tritium or iodine, continuous sampling with frequent analysis should be required. Consideration should also be given to continuous monitoring that can detect larger releases and/or continuous sampling to act as a substitute for waste receipt analysis and verification.

# REFERENCES

1. Conference of Radiation Control Program Directors, Inc. E-5 Committee, *Institutional Radioactive Wastes With Restrictions for Land Burial and Environmental Methods to Manage Such Waste*, DOE/LLW-5T, Nov. 1982.

2. EG&G Idaho Inc., *Improved Low-Level Radioactive Waste Management Practices for Hospitals and Research Institutions*, DOE/LLW-21T, July 1983.

3. USNRC, Division of Fuel Cycle and Material Safety, "Effective Radioactive Waste Management at Medical and Academic Institutions", Oct. 1981.

4. Roy Post (Editor), *Waste Management 85*, Proceedings of the Symposium on Waste Management at Tuscon, AZ, March 24-28.

5. Lecture Notes, *Incineration of Low Level Wastes: 1985*, Tuscon, AZ, March 21-23, 1985.

6. Conference of Radiation Control Program Directors, Inc., E-5 Committee, *Suggested State Requirements and Criteria for a Low-Level Radioactive Waste Disposal Site Regulatory Program*, NUREG/CR-4352, Aug. 1985.

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# ANNOTATED BIBILIOGRAPHY
# OF USEFUL SUPPORTING DOCUMENTS

Andreacola, E.; Irrgang, G.

GENERATORS: CHOOSE INCINERATION SYSTEMS WITH CARE Hazardous Materials and Waste Management, pp. 27-28, September-October 1984.

To best ensure the installation of a successful system, waste generators should equip themselves with a knowledge of their wastes, their options, and their suppliers. In preparing to determine the needs for an incineration system, two elements should be considered before any others: waste composition and flow. In addition, it is prudent to anticipate and consider future changes in the waste generated. Most basically, hazardous wastes can be divided into three groups: (1) pure organics; (2) acid-producing wastes; (3) and ash-producing wastes.

If a decision is made to incinerate on-site, waste generators must become acquainted with the types of systems available. Common choices include: (1) liquid injection incinerators, (2) rotary kilns, (3) fluidized-bed incinerators, and (4) multiple-hearth incinerators.

Certain criteria should be considered in selecting the most effective supplier. It is important to ensure that those selected possess adequate experience in water incineration and in the incineration of a generator's particular wastes.

Bohme, G.

TREATMENT OF SOLID RADIOACTIVE WASTE Karlsruhe Nuclear Research Center, IAEA Interregional Training Course, September-October 1982.

The primary incentive for compacting waste is the savings resulting from volume reduction. Cost savings can be made for containers, interim storage, shipment, and final disposal.

Mechanical compaction has been used extensively in the nuclear industry for the consolidation of dry, active waste.

Possible processes are pressing, rolling, shredding, stamping, extrusion, and explosive forming. However, to date, only the first three have been applied for nuclear wastes because the criteria regarding the equipment utilized must include factors, such as:

1. dust generation (contamination spread out, increased fire and dust explosion hazards),
2. reliability,
3. maintenance,
4. efficiency,
5. susceptibility to contamination problems, and 6. bale-handling problems (loading and unloading).

Borham, M.

INCINERATION METHOD FOR VOLUME REDUCTION AND DISPOSAL OF TRANSURANIC WASTE
Waste Management '85, Proceedings of the Symposium on Waste Management at Tucson, Arizona, R. G. Post, ed., The Ralph M. Parsons Co., March 1985.

The Process Experimental Pilot Plant (PREPP) at Idaho National Engineering Laboratory (INEL) is designed to process 7 TPD (6.4 Mg/d) of transuranic (TRU) waste, producing 8.5 TPD (7.7 Mg/d) of cemented waste and 110 mS/min (at standard conditions) of combustion gases with a volume reduction of up to 17:1. The waste and its container are shredded, fed to a rotary kiln heated to 925°C, and then cooled and classified by a trommel screen. The fine portion is mixed with a cement grout, which is placed with the coarse portion in steel drums for disposal at the Waste Isolation Pilot Plant (WIPP).

The kiln off-gas is reheated to 1090°C to destroy any remaining hydro-carbons and toxic volatiles. The gases are cooled and passed in a venturi scrubber to remove particulates and corrosive gases. The venturi off-gas is passed through a mist eliminator and is reheated to 28°C above the dew point prior to passing through a High Efficiency Particulate Air (HEPA) filter. The scrub solution is concentrated to 25% solids by an inertial filter. The sludge, containing the combustion chemical contaminants, is encapsulated with the residue of the incinerated waste.

Bourduin, L. C.; Neuls, A. S.

COMMERCIAL INCINERATION DEMONSTRATION LA-UR-81-3494, Los Alamos National Laboratory, 1981.

Low-level radioactive wastes (LLRW) generated by nuclear utilities presently are shipped to commercial burial grounds for disposal. Substantially increasing shipment and disposal charges have sparked renewed industrial interest in incineration and other advanced volume-reduction techniques as potential cost-saving measures. Repeated inquiries from industry sources regarding LLRW applicability of the Los Alamos controlled-air incineration (CAI) design led DOE to initiate this commercial demonstration in FY-1980. The selected program approach to achieving CAI demonstration at a utility site is a DOE-sponsored joint effort involving Los Alamos, a nuclear utility, and a liaison subcontractor. Required development tasks and responsiblities of the participants are described. Target date for project completion is the end of FY 1985.

Bourduin, L. C.; Taboas, A. L.

PLANT SAFETY FEATURES
Nuclear Safety, Vol. 22, No. 1, pp. 56-69, January-February 1981.

The current inventory of low level radioactive waste (radwaste) from defence and commercial industries is 2 x $10^6$ $m^3$ and increases $10^5$ $m^3$/year due to current operations. Most of this waste can be classified as combustibles, liquids and sludges, or noncombustible solids. The substantial combustible fraction, which has the greatest potential for effective waste treatment, constitutes an average of 40% of the newly generated waste. Proper incineration reduces waste mass and volume, results in a more homogeneous and chemically inert waste form, and also enhances the safety and certainty of waste handling, packaging, and storage and/or disposal operations. This article presents an introduction to incineration concerns and an overview of the prominent radwaste incineration processes being developed within the Department of Energy. Brief process descriptions, the status and goals of individual incineration systems, and planned or potential applications are also included.

Bourduin, L. C.; Taboas, A. L.

U.S. DOE RADIOACTIVE WASTE INCINERATION TECHNOLOGY: STATUS REVIEW
Los Alamos Scientific Laboratory, March 17, 1980.

The current inventory of radioactive waste from the defense and commercial industries is 2 x $10^6$ $m^3$ and increase $10^5$ $m^3$/year due to current operations. Most of this waste can be classified as combustibles, liquids and sludges, or as noncombustible solids. The very substantial combustible fraction, which has the greatest potential for effective waste treatment, constitutes an average of 40% of the newly generated waste. Proper incineration reduces waste mass and volume and results in a more homogeneous and chemically inert waste form that can usually be disposed where the original waste form could not. Further, incineration significantly enhances the safety and certainty of waste handing, packaging, storage, and/or disposal operations.

This paper presents an introduction to incineration concerns, and an overview of the prominent radwaste incineration processes being developed within DOE. Brief process descriptions, status and goals of individual incineration systems, and planned or potential applications are included.

Brownstein, M.; Witt, L.

INCINERATION OF LOW-LEVEL RADIOACTIVE MATERIAL
Waste Management '85, Proceedings of the Symposium on Waste Management at Tucson, Arizona, R. G. Post, ed., March 1985.

An advanced controlled-air pyrolysis incinerator has been developed and placed into operation for low-level radioactive wastes and has demonstrated the capability to incinerate ion-exchange resin. The resin incineration program has proven the ability of the incineration process to successfully incinerate varying mixtures of low-level, dry, active wastes and spent ion-exchange resins while maintaining off-gas contamination well below limits set by regulatory authorities.

Both commercial and nuclear installations have been operated, with the most recent application being a central incinerator for low-level radioactive waste presently being licensed in the United States. The NRC license for this facility is expected in mid-1984. This incinerator will process two million pounds (909 Mg) of dry, active waste and ion-exchange resin per year.

Cooley, L. R.; McCampbell, M. R.; Thompson, J. D.

CURRENT PRACTICE OF INCINERATION OF LOW-LEVEL INSTITUTIONAL RADIOACTIVE WASTE
EGG-2076, EG&G Idaho, Inc., February 1981.

During 1979, 142 medical and academic institutions were surveyed to assess the current practice of incineration of low-level radioactive waste. This was one activity carried out by the University of Maryland as part of a contract with EG&G Idaho, Inc., to site a radioactive waste incineration system. Of those surveyed, 46 (approximately 32%) were presently incinerating some type of radioactive waste. All were using controlled air, multistage incinerators. Incinerators were most often used to burn animal carcasses and other biological wastes (96%). The average size unit had a capacity of 113 kg/h. Disposal of liquid scintillation vials posed special problems; eight institutions incinerated full scintillation vials, and five incinerated scintillation fluids in bulk form. Most institutions (87%) used the incinerator to dispose of other wastes in addition to radioactive wastes. About half (20) of the institutions incinerating radioactive wastes reported shortcomings in their incineration process. Frequently cited reasons for incinerating wastes were: (1) a lower cost as compared with shipping for commercial shallow-land burial, (2) volume reduction, (3) convenience, and (4) closure of existing disposal sites.

Dam, A. S.; Bradley, M. J.

A COMPARISON BETWEEN MOBILE VR SERVICES AND CENTRAL VR SERVICE FACILITY FOR DRY ACTIVE WASTE Waste Management '85, Proceedings of the Symposium on Waste Management at Tucson, Arizona, R. G. Post, ed., Vol. 2, pp. 539-42, March 1985.

Low-level radioactive dry wastes can be volume-reduced using either mobile or central facilities with super-compactors, or incinerators, or both. This paper compares the technical, operational, and economic factors for mobile versus central facilities. Analyses indicated that customer costs, in addition to the service vendors fee, are a significant factor in the evalution of mobile services. The most attractive option is a central facility offering both incineration and super-compaction.

Dames & Moore

DE MINIMIS WASTE IMPACTS ANALYSIS METHODOLOGY
NUREG/CR-3S85
Division of Waste Management, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, February 1984

A calculational methodology is presented which can be used to estimate impacts from disposal of radioactive waste by less restrictive means ("de minimis" waste disposal). The methodology consists of two computer codes: one which determines annual radiological impacts to individuals and to populations from release of de minimis waste into less restrictive disposal pathways, and another which determines limiting concentrations of radionuclides based upon comparison with a set of individual dose limitation criteria. Operational impacts are calculated for de minimis waste transportation, treatment by incineration, and disposal. Long-term impacts after disposal (e.g., groundwater migration) are also calculated as are possible impacts from recycle of metal or glass. Alternatives for waste treatment/disposal include on-site, off-site as a municipal waste, and off-site as a hazardous waste.

Deltete, C. P.; Daloisic, G. S.; Wilson, R. B.

IDENTIFICATION OF RADWASTE SOURCES AND REDUCTIONS TECHNIQUES, VOLUME 3: DATA BASE
EPRI NP-3370, Gilbert Associates, Inc., January 1984.

The Electric Power Research Institute (EPRI) commissioned an operations-related project (RP1557-3) in late 1981 to develop a methodology which can be used by utility operations managers in evaluating the radwaste generation rates at their nuclear stations and to help them identify successful volume minimization techniques which can be applied to reduce these radwaste sources. The result of the project is a three-volume report comprising radwaste-related information from over two-thirds of the operating nuclear plants in the country as of December 31, 1981. Volume 1 is intended to serve primarily as a "handbook" and includes: (1) the major conclusions obtained throughout the report, (2) a method to evaluate a plant's waste management program effectiveness in minimizing radwaste generation in comparison to industrial performance, and (3) radwaste volume minimization techniques successfully used at operational nuclear stations. Volume 2 describes the project's technical approach and provides detailed evaluations of the waste source/characteristics data gathered during the project, while Volume 3 provides the entire computerized data base of plant waste sources and characteristics used in the project.

Department of Energy

FINAL ENVIRONMENTAL IMPACT STATEMENT INCINERATION FACILITY FOR RADIOACTIVELY CONTAMINATED PCBs AND OTHER WASTES DOE/EIS-0084, U.S. Department of Energy, June 1982.

The statement assesses the environmental impacts associated with the construction of an incineration facility and related support facilities for the disposal of hazardous organic waste materials (including PCBs) which are contaminated with trace quantities of low-assay enriched uranium. The proposed action includes the incineration facility at Oak Ridge, Tennessee, and storage, packaging, and shipping facilities at the Gaseous Diffusion Plants in Paducah, Kentucky, and Portsmouth, Ohio; hazardous organic wastes from these plants and from the Y-12 Plant and Oak Ridge National Laboratory would be shipped to the proposed incineration facility. Impacts assessed include the effects of the project on air and water quality, socioeconomic conditions, public and occupational health and safety, and ecology. Additionally, the statement presents an assessment of the potential impacts from accidents at the incineration facility or during transportation of the waste materials to the facility.

Diaz, N. J. (Technical Program Chairman)

Transactions of the American Nuclear Society
Vol. 38, p. 199, June 1981.

This volume includes the following article: "Design and Operation of a Prototype Incinerator for Beta-Gamma Waste."

DiSalvo, R.

LICENSING EXPERIENCE FOR A CENTRALIZED LLW INCINERATION FACILITY
Incineration of Low-Level Radioactive Wastes: 1985, Lecture
Notes, Tucson, Arizona, pp. DD1 to DD11, March 1985.

Battelle's Columbus Laboratories has applied to the U.S. Nuclear Regulatory Commission for authorization to incinerate low-level radioactive wastes. The proposed incinerator is the focal point of a research and demonstration program investigating the technical and economic viability of central site incineration. Earlier progress on this program was presented in a previous technical conference. This paper describes recent experience toward receiving regulatory authorization.

Dodge, R. L.; Edwards, C. W.; Wilson, B.

LICENSING REQUIREMENTS FOR BACKFIT INCINERATORS AT COMMERCIAL
NUCLEAR POWER PLANTS
ECG-M-19383, EG&G Idaho, Inc., 1984.

This paper, and the project it reports on, examines the licensing requirements for backfit incinerators at operating power plants. Analysis was made of incinerating low-level dry radioactive waste in a backfit incinerator at an existing power plant. The operation of the incinerator has been studied from viewpoints of operator safety, consequence of system failures including "worst case" scenarios, and radiological impact for normal and upset conditions. Analysis showed that releases under all normal operating or upset conditions are an extremely small fraction of the applicable limits. Nuclear Regulatory Commission review concluded that the document produced as a result of this project was useful as a design guide and of value in licensing backfit incinerators.

EG&G Idaho. Inc.

IMPROVED LOW-LEVEL RADIOACTIVE WASTE MANAGEMENT PRACTICES FOR
HOSPITALS AND RESEARCH INSTITUTIONS
DOE/LLW-21T, National Low-Level Radioactive Waste Program
June 1983

This report provides a general overview and a compendium of source material on low-level radioactive waste management practices in the institutional sector. Institutional sector refers to hospitals. universities, clinics, and research facilities that use radioactive materials in scientific research and the practice of medicine and the manufacturers of radiopharmaceuticals and radiography devices.

This report provides information on effective waste management practices for institutional waste to state policymakers, regulatory agency officials, and waste generators. It is not intended to be a handbook for actual waste management. but rather a sourcebook of general information, as well as a survey of the more detailed analyses.

Farinoso, F. S.; Wilson, R. B.

RADWASTE INCINERATOR EXPERIENCE
EPRI NP-3250, Gilbert Associates, Inc., October 1983.

RP1557-4 is a detailed survey of the current status of operating low-level radioactive waste (LLRW) incinerators, and it compares the technology to the design requirements for use at U.S. nuclear power plants. Data are presented on incinerator design and performance for operating facilities and development prototypes in Europe, Japan, Canada, and the United States. The systems are described by subsystem categories: feed preparation, combustion chamber, off-gas treatment, and ash handling. The history of operations and maintenance is included for these operating facilities.

The incinerator types that will most likely be utilized at U.S. nuclear power plants are discussed to assess their licensability under U.S. regulations in light of the operational performance achieved on a worldwide basis.

Frankel, I.; Sanders, N.; Vogel, G.; Lee, C. C.

PROFILE OF THE HAZARDOUS WASTE INCINERATOR MANUFACTURING INDUSTRY
WP-81W00433, MITRE Corporation, McLean, Virginia, 1981.

The purpose of this document is twofold:

1. to present information on the number, types, and capacities of hazardous waste incinerators put into operation since January 1969, and
2. to present information which analyzes and describes some of the more important design features of the various types of incinerators.

Virtually every incinerator facility now in hazardous waste service in the United States should be equipped with at least one air pollution control device (APCD). The addition of APCDs does, of course, significantly add to incinerator capital cost requirements and operating expenses. Within the past few years, the value of thermal energy has greatly appreciated, and thermal energy release from incinerators can be significant. Accordingly, this study has shown that almost 90% of all hazardous waste incinerator facilities ordered or placed into operation during the past year have been equipped with energy recovery subsystems.

Goodings, W.; Pojasek, R.; Laughlin, R.; et al.

GENERIC PROCESS TECHNOLOGIES STUDIES
Proctor and Redfern Group, Ontario Waste Management Corporation, August 1982.

The purpose of this report is to identify and evaluate liquid industrial waste and hazardous waste abatement, treatment, and disposal technologies on a generic basis. Technologies described in this report are predominantly processes which have been adopted and successfully demonstrated in full scale applications.

The technology descriptions and evaluations in this report represent an initial screening of waste management technologies and serve as a "shopping list" for selection of appropriate special waste management strategies by the Province of Ontario. The six major technology categories described in this study are:

1. waste abatement, reduction, reuse, and recycle;
2. biological treatment;
3. physical/chemical treatment;
4. thermal processing or incineration;
5. solidification/stabilization and encapsulation; and
6. ultimate disposal.

Hashimot, K.; Koshiba, Y.

IMPROVING VOLUME REDUCTION METHODS IN JAPAN
Nuclear Engineering International, Vol. 28@ No. 338, pp. 47-48, March 1983.

Since 1970, JGC Corporation has been pursuing R&D in an attempt to develop improved radwaste treatment facilities. Work has concentrated on: (1) reducing both the radiation dose to plant personnel and environmental releases; (2) minimizing the amount of waste generated: radwaste volume reduction; and (3) effective solidification.

Three volume reduction techniques for various types of radwaste are either currently in use or about to be put into operation in Japan. They are: (1) incineration, (2) oxidation of ion exchange resin, and (3) recycling.

These three processes have been combined in the design of a novel radwaste treatment system. The system is built of six subsystems dealing with the various types of power station wastes.

Hayes, J. J.

NRC'S REVIEW CRITERIA FOR AN INCINERATOR UTILIZED AT A NUCLEAR POWER PLANT
Incineration of Low-Level Radioactive Wastes: 1985, Lecture Notes, Tucson, Arizona, pp. Z1 to Z7, March 1985.

Lack of available low level waste burial sites and increasing burial costs have necessitated that the operators of nuclear power plants consider various volume reduction alternatives. One of these is incineration.

Incinerators are currently planned for four plant sites serving a total of nine reactors and will be the first use of this technology at a nuclear power plant since the early 1960s. Incineration, except for small vials of liquid scintillation detector fluids or animal carcasses containing tritium or $^{14}C$, requires NRC approval. This paper presents the NRC's review criteria for an incinerator utilized at a nuclear power plant.

Henderson, J. D.; Boyd, M. A.; Marshall, R.

OPERATING EXPERIENCE WITH A DRY, ACTIVE WASTE SHREDDER/COMPACTOR AT A NUCLEAR POWER PLANT
Waste Management '85, Proceedings of the Symposium on Waste Management at Tucson, Arizona, R. G. Post, ed., Vol. 2, pp. 523-28, March 1985.

Dry, active waste (DAW) produced at nuclear power plants generally accounts for a large portion of the total low-level radioactive waste shipped for disposal at shallow-land burial sites. Dry, active waste generally consists of paper, cloth, scrap wood, light metals, sheet plastics, and other miscellaneous items. Most nuclear plants package the compactible waste with either a drum or box compactor. Noncompactible waste is packaged in either metal or wooden boxes. The shredder/compactor system was developed to shred normally bulky noncompactible waste and thus make it capable of being compacted into an LSA box with other compactible waste. The result is the elimination of void spaces, reduced springback tendency, and an increase in the density of the waste which can be compacted into a box.

Carolina Power & Light Company installed a shredder/compactor system at the Brunswick Steam Electric Plant in October 1984. This paper describes the shredder/compactor system, the performance of the system using a simulated EPRI waste mixture, the system performance using a simulated Brunswick plant DAW mixture, and system operating experience.

Herald, W. R.; Klingler, L. M.

MOUND CYCLONE INCINERATOR, VOLUME II. ENGINEERING DESIGN REFERENCE MANUAL
MLM-MU-81-72-0003, Monsanto Research Corporation, January 1982.

The materials and information included in this volume reflect the actual operating system now in use at Monsanto's Mound Facility located in Miamisburg, Ohio. Restraints resulting from using existing equipment, facilities, and room geometry necessitated designing an incinerating system with nonoptimum engineering standards. To design a nearer-to-optimum operating incinerator, the drawings can be easily modified and adapted to fit many different room geometries and conditions. This versatility is one of the major advantages of the cyclone incinerator.

JACA Corporation

INCINERATION AND TREATMENT OF HAZARDOUS WASTE - PROCEEDINGS OF THE TENTH ANNUAL RESEARCH SYMPOSIUM AT FT. MITCHELL, KENTUCKY
EPA-600/9-84-022, Environmental Protection Agency, April 1984.

The Tenth Annual Research Symposium on Land Disposal, Remedial Action, Incineration, and Treatment of Hazardous Waste was held in Fort Mitchell, Kentucky, April 3 through 5, 1984. The purpose of the symposium was to present to persons concerned with hazardous waste management the latest significant findings of ongoing and recently completed research projects funded by the Industrial Environmental Research Laboratory's Energy Pollution Control Division and the Municipal Environmental Research Laboratory's Solid and Hazardous Waste Research Division.

This volume is a compilation of speakers' papers and poster presenters' abstracts for Session B, Hazardous Waste Incineration and Treatment. Subjects include innovative technology, laboratory scale research projects, pilot- and full-scale incineration projects, combustion of hazardous waste in boilers and in industrial processes, and hazardous waste treatment and cost studies. This document covers hazardous waste incineration and treatment only. A separate document for Session A, Hazardous Waste Land Disposal, is available from the Municipal Environmental Research Laboratory.

Jessop, D.; McRee, B.

OPERATION OF CONTROLLED-AIR INCINERATORS AND DESIGN CONSIDERATIONS FOR CONTROLLED-AIR INCINERATORS TREATING RADIOACTIVE WASTES
Incineration of Low-Level Radioactive Wastes: 1985, Lecture Notes, Tucson, Arizona, p. A1, March 1985.

The intent of this paper is to review design philosophy of all controlled-air incinerators and make conclusions concerning the proper operation of this equipment. It also discusses special considerations in the design of incinerators treating radioactive wastes. The paper will provide a brief history of controlled-air incineration and define the term "controlled air." In order to fully understand the principles of controlled-air incineration, some basic chemistry of combustion will be presented. The paper discusses excess air and how it affects operating parameters, including chamber temperatures, effluent compositions, and particulate emissions. The conditions and processes taking place within a controlled-air incinerator will be summarized. A series of commonly incinerated waste materials will be examined so that operating parameters, such as combustion temperatures and amount of excess air,can be established. The paper will specifically address the incineration of materials high in fixed carbon content and describe how they are handled in controlled-air incinerators. Finally, the paper will present some special design and operating requirements for incinerators treating radioactive materials.

Katsikis, E. P.

INCINERATION OF LOW-LEVEL RADIOACTIVE WASTE: DESIGN, RECIPE AND ANALYSIS
Incineration of Low-Level Radioactive Wastes: 1985, Lecture Notes, Tucson, Arizona, pp. W1 to W4, March 1985.

Design specifications for an incinerator should be such that it is capable of handling low-level radioactive, pathological (usually of large volume), and hazardous waste. Ash that does not contain residual radioactivity and/or hazardous constituents (scintillation media) can be removed to a sanitary landfill. Incineration can reduce the volume of waste and render it nonradioactive and nonhazardous, therefore innocuous to the environment. Proper incinerator design parameters, a recipe for charging the waste, and analytical procedures together will help achieve environmentally sound volume reduction.

Katsikis, E. P.

PART B PERMIT: INCINERATION OF SCINTILLATION VIALS
Incineration of Low-Level Radioactive Wastes: 1985, Lecture Notes, Tucson, Arizona, pp. CC1 to CC3, March 1985.

Incineration is the most responsible disposal method for scintillation vials. It reduces the volume and renders the ash nonhazardous when proper design parameters are followed. Meticulous analyses procedures will ensure that the ash will be delisted under RCRA and that disposal in a sanitary landfill will be permitted.

Although scintillation vials containing $^{14}C$ and $^{3}H$ in amounts less than 0.05 µCi/g are not regarded by the Nuclear Regulatory Commission as radioactive waste, the xylene, toluene, and 1,4-dioxane frequently used as the solvent base for scintillation media are listed by the U.S. Environmental Protection Agency as hazardous.

King, S. H.; Miller, K. L.; Erdman, M. C.

AN OVERVIEW OF AN INSTITUTIONAL INCINERATION PROGRAM
Incineration of Low-Level Radioactive Wastes: 1985, Lecture Notes, Tucson, Arizona, pp. Q1 to Q6, March 1985.

Rising costs and the uncertainty of low-level radioactive waste disposal site availability have put a burden on generators to find every means possible of reducing the volumes of such waste. This is especially true at institutions with limited storage capacity. The reclassification of liquid scintillation fluids and animal carcasses containing $^{3}H$ or $^{14}C$ have made incineration an attractive alternative to shipment for burial. Research at the Hershey Medical Center has also shown that animal carcasses containing certain gamma-emitting radioisotopes can be incinerated with very high recoverability of the radioisotopes in the ash. Our experience in developing an incineration program, the equipment involved, sampling performed, and cost-effectiveness are reviewed.

Klingler, L. M.

CYCLONE INCINERATOR - OPERATING EXPERIENCE
MLM-3094, Monsanto Research Corporation, September 1983.

The cyclone incinerator, developed at Mound Laboratory in the mid to late 1970s has proven to be a valuable tool for the volume reduction of the plant s combustible radioactive wastes.

The incinerator has effected a significant reduction in Mound's offsite waste shipping requirements. More than 27 tons (24.5 Mg) of plutonium-contaminated wastes have been incinerated in the system at volume reduction factors of greater than 95%. Moreover, the extreme simplicity of the system in principle, design, components, and operation has resulted in extremely low maintenance cost and real plant cost savings in waste handling and disposal over the past several years.

The cyclone incinerator has more potential plant users than available operating time. In addition to burning dry solids, incineration feasibility has been demonstrated for wastes that present special disposal problems to the plant. These wastes include combustible liquids, scintillation vials, and tritium-contaminated, dry, solid wastes.

Klingler, L. M.

MOUND CYCLONE INCINERATOR VOLUME I. DESCRIPTION AND PERFORMANCE
MLM-MU-81-72-0003, Monsanto Research Corporation, December 1981.

The Mound cyclone incinerator, developed by Monsanto, was designed to fill a need for a simple, reliable incinerator for volume reduction of dry, solid waste contaminated with 238Pu. Although the basic design of the incinerator is for batch burning of solid combustible waste, the incinerator has also been adapted to volume reduction of other waste forms. Specialized waste feeding equipment enables continuous burning of both solid and liquid waste, including full scintillation vials. Modifications to the incinerator off system enable burning of waste contaminated with isotopes other This makes the incinerator useful for volume reduction of waste from a variety of nuclear facilities, such as medical, research, power plants, and reprocessing operations. This document presents the design and performance characteristics of the Mound cyclone incinerator for incineration of both solid and liquid wastes. Suggestions are included for adaptation of the incinerator to specialized waste materials, and possible improvements have been included as appropriate.

Leduc, R. J.

OPERATING EXPERIENCE WITH A HIGH-FORCE COMPACTOR
Incineration of Low-Level Radioactive Wastes: 1985, Lecture Notes, Tucson, Arizona, pp. H1 to H9, March 1985.

Dry, activated waste (DAW) produced at nuclear power plants accounts for the largest fraction of the radioactive waste volume generated and shipped for burial. The application of advanced volume reduction techniques to DAW is now even more important as the time for potentially significant reductions in burial space allocation approaches. This paper discusses the design features, operating performance, and economic advantages of the Westinghouse Hittman mobile high-force compaction service. COMPACT I is a technology that can be applied today without the corresponding capital expenditures and licensing efforts required of incineration.

Lewandowski, K. E.

A SAVANNAH RIVER PLANT INCINERATOR DEMONSTRATION
DP-MS-83-90, E. I. du Pont de Nemours & Co., 1983.

A full-scale incineration process was demonstrated at the Savannah River Laboratory (SRL) using nonradioactive wastes. From October 1981 through September 1982, 15,700 kg of solid waste and 5.7 $m^3$ of solvent were incinerated. Emissions of off-gas components ($NO_x$, $SO_2$, CO, and particulates) were well below South Carolina state standards.

Volume reductions of 20:1 for solid waste and 7:1 for Purex solvent/lime slurry were achieved.

The process has been relocated and upgraded by the Savannah River Plant to accept low-level, beta-gamma combustibles. During a 2-year demonstration, the facility will incinerate slightly radioactive ($<1.7$ mCi/$m^3$) solvent and suspect level ($<1$ mR/h at 2.5 cm) solid wastes.

Lysen, P.

LICENSING EXPERIENCE WITH LARGE INCINERATORS
Incineration of Low-Level Radioactive Wastes: 1985, Lecture Notes, Tucson, Arizona, pp. EE1, March 1985.

The NRC's Office of Nuclear Material Safety and Safeguards (NMSS) has under active review two license applications for operation of large incineration systems for volume reduction of low-level radioactive waste. One application is by Battelle Columbus Laboratories for a demonstration program using the German Draftanlagen incinerator design; the other is by Babcock & Wilcox for a volume reduction facility using the Aerojet Energy Conversion Company's mobile incinerator system. Additionally, NMSS is assisting our Office of State Programs, which was asked by the State of North Carolina to review U.S. Ecology's application for a license to operate an incinerator to be built by Associated Technologies.

While no conclusions have yet been reached regarding the acceptability of the applications, the main issues that must be considered have become clear. First and foremost is that of effluents from routine operation of a facility--their control, measurement, and impact. Other issues include occupational exposure from routine operations and maintenance, waste/product management, and impacts from postulated accidents and transportation.

Martin Marietta Energy Systems, Inc.

TSCA OAK RIDGE PCB INCINERATION FACILITY-PROCUREMENT SPECIFICATION FOR THE FEED, INCINERATOR AND OFF-GAS TREATMENT SYSTEMS
Martin Marietta Energy Systems, Inc., August 30, 1984.

This specification covers the "turnkey" requirements for the design, procurement, fabrication, installation or construction, start-up, and performance testing of an integrated facility for incineration and off-gas treatment of hazardous organic waste materials, including polychlorinated biphenyls (PCBs) which may be contaminated with low-assay uranium ($<1\%$ $^{235}U$).

Maughan, R.

LOW-LEVEL WASTE INCINERATION AT THE IDAHO NATIONAL ENGINEERING LABORATORY
Incineration of Low-Level Radioactive Wastes: 1985, Lecture Notes, Tucson, Arizona, pp. K1, March 1985.

A facility for the incineration of low-level, beta/gamma-contaminated combustible waste has been constructed at the Waste Experimental Reduction Facility (WERF) at the Idaho National Engineering Laboratory (INEL). The incineration facility was established to: (1) reduce the volume of currently generated contaminated combustible waste being disposed at the INEL's radioactive waste disposal site and thereby prolong the site's useful life, and (2) develop waste processing technology by providing a facility where full-size processes and equipment can be demonstrated and proven during production-scale operations.

Cold systems testing has been completed, and contaminated operations began in September 1984. Currently, the facility is processing waste packaged in 2 x 2 x 2 ft (0.6 x 0.6 x 0.6 m) cardboard boxes and measuring <10 mR/h at contact.

Meile, L. J.; Meyer, F. G.; Johnson, A. J.; Ziegler, D. L.

ROCKY FLATS PLANT FLUIDIZED-BED INCINERATOR
RFP-3249, Rockwell International, March 1982.

Laboratory- and pilot-scale testing of a fluidized-bed incineration process for radioactive wastes led to the installation of an 82-kg/h demonstration unit at Rocky Flats Plant in 1978. Design philosophy and criteria were formulated to fulfill the needs and objectives of an improved radwaste incineration system. Unique process concepts include low temperature (550°C), flameless, fluidized-bed combustion, and catalytic afterburning; in situ neutralization of acid gases; and dry off-gas cleanup. Detailed descriptions of the process and equipment are presented along with a summary of the equipment and process performance during a 2.5 year operational testing period. Equipment modifications made during the test period are described. Operating personnel requirements for solid waste burning are shown to be greater than those required for liquid waste incineration; differences are discussed. Process utility and raw materials consumption rates for full capacity operation are presented and explained. Improvements in equipment and operating procedures are recommended for any future installations. Process flow diagrams, an area floor plan, a process control system schematic, and equipment sketches are included.

Michlink, D. L.; Marshall, D. L.; Turner, V.; et al.

THE FEASIBILITY OF SPENT RESINS INCINERATION AT NUCLEAR POWER PLANTS
Waste Management '83, Proceedings of the Symposium on Waste Management at Tucson, Arizona, R. G. Post, ed., Vol. 1, pp. 439-43, March 1983.

Due to the chemical nature and potentially high curie content of spent ion exchange resins, the nuclear industry has moved with caution in the incineration of the spent resins and solidification of the resultant ash. In November 1981, Aerojet finished an extensive ion exchange resin incineration test program which was closely monitored by TVA. The data from the test program provided insight into the resin incineration process and resultant product. The data verified that incineration of spent ion exchange resins is a feasible means of reducing the overall volume of radwaste requiring disposal. However, care must be exercised in the basic process used for incineration of resins, the cleanup of the resultant off-gas, and the disposal of the scrub solution generated by the off-gas cleanup system. This paper discusses in further detail the subject of spent resin incineration.

National Low-Level Radioactive Waste Management Program

INSTITUTIONAL RADIOACTIVE WASTES WITH RESTRICTIONS FOR LAND BURIAL AND ENVIRONMENTAL METHODS TO MANAGE SUCH WASTE
DOE/LLW-5T, EG&G Idaho, Inc., November 1982.

Decisive actions must now be taken within a relatively short time to allow for the uninterrupted use of radioactive materials that have been beneficial to mankind. Of particular concern are certain types of radioactive wastes generated by institutions (such as hospitals and universities), which have been restricted from land burial by some of the existing commercial disposal sites. Although usually relatively low in radioactivity, the restricted institutional wastes may be chemically or pathogenically toxic, or the chemicals may degrade disposal site performance.

This document has been developed by state government radiation control personnel with the purpose of identifying the specific types of such institutional wastes that have some type of restrictions on availability for shallow-land burial, and further, of identifying methods that can be applied to the management of such wastes and that would be environmentally acceptable. Special emphasis was given to incineration as one method of reducing the volume of such wastes.

National Low-Level Radioactive Waste Management Program

RADIOACTIVE WASTE INCINERATION AT PURDUE UNIVERSITY
DOE/LLW-12T, EG&G Idaho, Inc., November 1982.

This report describes a study conducted at Purdue University to evaluate the feasibility of using a small (45-kg/h), inexpensive (less than $10,000) incinerator for incinerating low-level radioactive waste. An oil-fired, dual-chamber, pathological waste incinerator was installed on a 12.7-cm-thick concrete floor in a metal quonset building. A standard EPA Method 5 sampling train was used to obtain stack samples. Also, stack gas velocity was measured with a type 5 pitot tube; stack temperature was measured with a thermocouple and a pyrometer.

Results of the study demonstrated the feasibility and cost-effectiveness of incinerating radioactive animal carcasses and liquid scintillation fluids, since emissions from those waste types were within EPA and State of Indiana limits. However, emissions from the burning of trash exceeded State of Indiana limits. Therefore, incineration of trash alone, particularly if it contains glass or significant amounts of plastic, is not a recommended use of the tested equipment.

Ohrn, G.

INCINERATION OF LOW-LEVEL DAW - OPERATING EXPERIENCE AT STUDSVIK, SWEDEN
Incineration of Low-Level Radioactive Wastes: 1985, Lecture Notes, Tucson, Arizona, pp. J1 to J23, March 1985.

Studsvik operates a central incinerator facility serving 25 nuclear waste generating customers in Sweden and Germany. The plant is operating at a current capacity of 425 metric tons (Mg) of DAW incineration per year. Operating experience dates from 1976, and the cumulative total of waste incinerated amounts to about 2000 metric tons (Mg), which is roughly equivalent to 20,000 $m^3$ of unprocessed waste. The plant has operated with a 95% availability factor since commissioning. Technical details of the incinerator system, operational characteristics, and operational experience are discussed.

Oyen, L. C.; Tucker, R. F., Jr.

ADVANCED LOW-LEVEL RADWASTE TREATMENT SYSTEMS
EPRI-NP-1600, Sargent and Lundy, October 1980.

A survey of the present status of commercial radwaste volume reduction (VR) activity in the United States is presented. Volume reduction is defined, and a set of categories for VR processes is given, namely (1) crystallization, (2) dehydration, (3) compaction, and (4) incineration. Some examples of the effects of these processes are given, and their realms of applicability are illustrated. A "typical" economic assessment is given with methods and assumptions stated in detail, showing conditions under which VR equipment can be cost-effective. System descriptions are given for nine currently, and four potentially, commercially available VR systems.

The types of systems treated include evaporative crystallizers, both forced circulation and thin-film types; fluidized-bed dryers; bitumen dryer and solidification systems; a blender/evaporator dryer; an inert carrier evaporator-dryer; and fluidized-bed incinerators, controlled-air incinerators, and excess-air, solid-bed incinerators, as well as a glass furnace used as an incinerator/calciner.

Pitchford. T. L.; et al.

> LOW-LEVEL RADIOACTIVE WASTE MANAGEMENT AT THE university OF M1SSOUR1
> Incineration of Low-Level Radioactive Wastes: 1985, Lecture Notes, Tucson, Arizona, pp. R1 to R7, March 1985.

The University of Missouri uses by-product material at four widely separated campuses, at a research reactor, and at locations elsewhere in the state. Coordination of the radiation control program is accomplished by the central Office of Research Safety. For reasons of economy, the management of the radioactive waste program has become partly centralized. Some wastes generated by the Research Reactor Facility and nearly all the wastes generated at three of the four campuses are collected, evaluated, and separated by each of the respective health physics organizations. The waste separation categories are: (1) materials that may be disposed of locally, (2) material that should be held for decay prior to any processing, (3) material that may be incinerated, and (4) material that must be shipped to a licensed burial site. This paper describes the organizational coordination and the specific procedures that are employed for processing the waste for incineration.

Rickman, W. S.

> CIRCULATING-BED INCINERATION OF RADIOACTIVE AND HAZARDOUS WASTES
> Incineration of Low-Level Radioactive Wastes: 1985 Lecture Notes, Tucson, Arizona, pp. N1 to N12, March 1985.

Recent operating experience on circulating-bed waste incinerators has demonstrated clean, efficient, and economical treatment of a variety of low-level radwastes. Wastes being processed today include: (1) granular carbon with heavy-metal chlorides, (2) uranium-bearing oil sludge, and (3) chunks of graphite containing fission product waste. These and other wastes are classified and regulated now by both the EPA and the NRC, with a much tighter set of regulations than ever before. GA's circulating-bed waste incinerator systems have received all permits based on their demonstrated ability to: (1) destroy hazardous constituents to >99.999% efficiency - without afterburners or auxiliary fuel, (2) retain >99% of all HCl emissions - without wet scrubbers, and (3) meet all EPA and NRC particulate emission standards using dry filters that are continuously cleaned on-line. Photographs and cutaway drawings of several of the over 25 current installations are presented, along with specific operational performance data.

Rickman, W. S.; Holder, N. D.; Young, D. T.

CIRCULATING-BED INCINERATION OF HAZARDOUS WASTES
Chemical Engineering Progress, Vol. 81, No. 3, pp. 34-38, March 1985.

Circulating-bed waste incinerators operate cleanly, efficiently, and economically. Their simple design uses high turbulence in the reaction zone to eliminate afterburners, scrubbers, or multiple feeders. Proven performance on industrial wastes includes the following benefits:

1. combustion efficiency, >99.999%;
2. HCl capture, >99%;
3. no scrubbers or wet sludge product;
4. no afterburners or auxiliary fuel;
5. highest boiler efficiency in industry;
6. waste volume reduction up to 40:1;
7. recovery of valuable chemicals;
8. single-point feeding, even up to 100 million Btu/h (35 MW, thermal); and
9. $NO_x$ and CO emissions, <100 ppm (100 mg/L).

Rickman, W. S.; Holder. N. D; Young, D. T.

CIRCULATING-BED INCINERATION OF HAZARDOUS WASTES
Presented at American Institute of Chemical Engineers 1984 Summer National Meeting, GA Technologies, August 1984.

Across the nation, landfills and deep-well injection appear to be on their way out as acceptable methods for hazardous waste disposal. Several recent studies of industrial waste management in the United States have pointed out the need for more vigorous development of alternatives. An alternative to simple disposal of wastes is treatment. For many waste types, incineration is the best treatment method. In a well-designed incineration system, the following benefits should be realized:

1. destruction of hazardous compounds.,

2. retention of acid gases such as HCl;
3. reduction of volume;
4. recovery of heat; and
5. recovery of valuable chemicals.

This paper describes circulating-bed incineration, an advanced type of incinerating proven to meet all of these criteria with a simple, effective design.

Ross, R.

THE APPLICABILITY OF VARIOUS INCINERATION SYSTEMS TO LOW-LEVEL RADIOACTIVE WASTE
Incineration of Low-Level Radioactive Wastes: 1985, Lecture Notes, Tucson, Arizona, pp. D1 to D19, March 1985.

A number of new, and sometimes unique, incinerator concepts have been developed in the last 3 to 5 years which, while virtually unproven on a commercial scale, suggest that the field of incineration technology will be employed to a greater extent in the future. The incineration of low-level radioactive waste has been accomplished in the past by using a variety of incinerator designs, temperatures, materials, and particulate removal systems. To add to the growing list of possibilities, this paper examines several new techniques in detail to assess their possible future use as low-level radioactive waste incineration systems.

The incineration systems that will be analyzed for applicability include the Arc Technologies process, which destroys organic materials in a high-temperature electric-arc furnace; the Penberthy Electromelt System, which uses molten glass to capture the ash; the PEDCO cascading fluid-bed system; and the MODAR sypercritical water system for low concentration of organic-inorganic-aqueous wastes. The aspects of air pollution control and disposal of the ash will also be discussed for each system.

Ross, R. D.

HAZARDOUS WASTE INCINERATION: MORE ATTRACTIVE NOW THAN EVER BEFORE
Hazardous Materials and Waste Management Magazine, pp. 13-19, September-October 1984.

Recent legislation has made incineration an attractive option in waste management. The technologies involved in the incineration of industrial waste include: (1) liquid injection, (2) rotary kiln, (3) fluid bed, (4) multiple-hearth incinerator, (5) starved-air or, as it is called now, controlled-air incinerator.

There are many processes that are new in incineration, but the seven that are listed cover the fairly wide spectrum of the types of systems that may be considered in the future. They include: (1) circulating-bed combustor, (2) molten-salt technology, (3) Penberthy Electro-Melt System, (4) advanced electric reactor, (5) supercritical water, and (6) vertical-tube reactor.

### Societe Generale Pour Les Techniques Nouvelles - SGN

RADWASTE INCINERATION SYSTEM
Societe Generale Pour Les Techniques Nouvelles, November 1984.

The CEA Group has developed a radwaste incineration system which includes preliminary sorting of wastes, gas treatment, and conditioning of ashes. The ash-conditioning system is compatible with other residues and can be adapted to meet the specific requirements of each project.

The incinerator comprises a two-combustion chamber system:

1. The first is equipped with special, patented grates particularly adapted to plastics and rubber.
2. The second, the post-combustion chamber, is filled with patented refractory material which is highly efficient in the destruction of unburnt solid or gaseous residues.

### Sprau, D. D.; Lao, Y. J.; Gaiser. J.

INCINERATION OF LOW-LEVEL RADIOACTIVE WASTE--UP THE STACK
WITHOUT A MONITOR!
Incineration of Low-Level Radioactive Wastes: 1985, Lecture
Notes, Tucson, Arizona, pp. S1 to S2, March 1985.

For the past 2 years, we have been monitoring the incinerator used by the East Carolina University School of Medicine for low-level radioactive waste disposal. Our monitoring program has consisted of (1) periodic air sampling in the incinerator stack; (2) sampling ash to determine radionuclide content; (3) contamination surveys around the incinerator; and (4) determining activity and radionuclides within the incinerator. Results of our monitoring have convinced us that low-level radioactive waste incineration remains, for the most part, an attractive disposal alternative. There are, however, some substantial problems in monitoring and knowing the activities of 1"C and tritium released in the stack effluent. These problems are the lack of on-line monitors for long waste burns and the time required for accurate laboratory analyses. The waste picked up in laboratories is often mislabeled with regard to activity. Activities are usually overestimated, but underestimations do occur. This problem, along with its effect on the future of low-level radioactive waste incineration, is discussed.

Stockinger, S. L.; Rossmassler, R. L.

THE CASE FOR INCINERATING AND SUPERCOMPACTING DRY ACTIVE WASTE AT THE STATE OR REGIONAL LEVEL
Incineration of Low-Level Radioactive Wastes: 1985, Lecture Notes, Tucson, Arizona, pp. I1 to I11, March 1985.

The "Low-Level Radioactive Waste Policy Act" placed the responsibility for ensuring adequate disposal capacity on each of the states. As an additional incentive, states and regional Compacts may restrict disposal to wastes generated within the region after January 1, 1986. The possibility of having no sites to which waste can be shipped is very high for many states. Many economic analyses have been performed by large generators of waste to justify volume reduction technology. It is time for states and regions to evaluate economic alternatives and to provide a total waste management plan for all generators. The data available are sufficient for many states and/or regions to justify volume reduction facilities. These facilities could contain an incinerator and/or a supercompactor. In addition to the basic economics, the volume reduction of dry, active waste (DAW), once disposed in a shallow-land burial site, will improve site stability and reduce long-term site maintenance. This paper examines the economics of such a facility and concludes that the economic viability exists and should be implemented.

Stretz, L. A.; Bourduin, L. C.; Draper, W. E.; et al.

CONTROLLED AIR INCINERATION OF HAZARDOUS CHEMICAL WASTE AT THE LOS ALAMOS NATIONAL LABORATORY
Los Alamos National Laboratory, circa 1980.

An incineration system, originally demonstrated as a transuranic (TRU) waste volume-reduction process, is described. The production-scale controlled air incinerator using commercially available equipment and technology was modified for solid radioactive waste service. The same incinerator and off-gas treatment system have been modified further for use in evaluating the destruction of hazardous liquid wastes such as polychlorinated biphenyls and hazardous solid wastes such as pentachlorophenol (PCP)-treated wood.

Results of a PCP-treated wood incineration test show a PCP destruction efficiency of greater than 99.99% in the primary chamber for the operating conditions investigated. Conditions and results for this test are described.

Sturchio, G. M.

IMPLEMENTATION AND ASSESSMENT OF A BIOLOGICAL RADIOACTIVE WASTE INCINERATION PROGRAM
Incineration of Low-Level Radioactive Wastes: 1985, Lecture Notes, Tucson, Arizona, pp. T1, March 1985.

The use of incineration to handle the disposal of biological low-level radioactive waste at the University of California at Davis is examined. A unique compromise agreement between the Sewage Treatment Plant staff and the Health Physics group has been established for use of the campus pathological incinerator, as well as administrative and technical protocols to ensure compliance with state radiation control regulations.

The development of criteria to limit the quantity of an isotope incinerated and to mitigate the need for stack monitoring will be discussed. Additionally, an assessment of the program will show significant savings, concomitant with a reduction in radioactive waste volume.

Treat, R. L.; Lokken, R. O.; Schliebe, M. J.

INCINERATION OF A TYPICAL LWR COMBUSTIBLE WASTE AND ANALYSIS OF THE RESULTING ASH
NUREG/CR-3087, PNL-4563, Pacific Northwest Laboratory, May 1983.

In this study, 4540 kg (10,000 lb) of simulated nuclear power plant combustible wastes was burned in a controlled-air incinerator. The purpose of this work was to generate ashes suitable for solidification, the products of which will be analyzed to determine if they are suitable for disposal. Two different types of waste were burned: (1) resins and simulated crud and (2) general trash (paper, plastics, wood, rubber, and cloth). Volume-reduction ratios (unburned waste: ash) were 13:1 and 22:1, respectively. Approximately 20% of the ash was lost due to adherence to incinerator walls and entrainment in the off-gas stream. Losses of the volatile species cesium and iodine were 79 and 100%, respectively. The ashes were not hygroscopic, but they exhibited a pH of 4.6 to 5.0 when water was added. Corrosion of mild steel drums would occur within this pH range. The ashes contained a significant quantity of clinkers having lengths as great as 20 cm (8 in.). Most of the clinkers were fully incinerated and easy to crush, suggesting that standard comminuting equipment should be effective in reducing the size of clinkers to allow their solidification with the fine ashes.

Trigilio, G.

VOLUME REDUCTION TECHNIQUES IN LOW-LEVEL RADIOACTIVE WASTE MANAGEMENT
NUREG/CR-2206, Teknekron, Inc., September 1981.

This report presents a comprehensive compilation and data base of volume reduction techniques for low-level radioactive wastes generated in fuel- cycle and non-fuel-cycle facilities. Discussions of the volume reduction techniques are provided to include system descriptions, system performance data, volume reduction capabilities, process parameters, system limitations, and operating experience. An economic analysis is presented for shredding and compaction, incineration, calcination, evaporation/crystallization, and bituminization. PWR, BWR, and non-fuel-cycle waste scenarios are evaluated for volume-reduction techniques used at a waste generator's facility and on a regional basis. The economic analyses estimate costs of capital equipment, construction, operation, processing, transportation, and disposal at the Barnwell, South Carolina, and Hanford, Washington, disposal sites.

Waters, R. M.; Moscardini, R. L.

DESIGN CONSIDERATIONS FOR LOW-LEVEL RADIOACTIVE WASTE COMBUSTORS
Waste Management '82, Proceedings of the Symposium on Waste Management at Tucson, Arizona, R. G. Post, ed., Vol. 2, pp. 497-505, March 1982.

Combustion Engineering's Waste Incineration System (C-E/WIS) uses suspension burning in an excess air atmosphere for maximum volume reduction and safety. Pyrolysis and starved-air combustion, when applied to the incineration of radioactive waste materials, must be considered with caution. All waste, from liquids through resin slurries to dry active wastes, cannot be handled effectively with these processes. The use of these designs results in less than maximum volume reductions and increases the potential for unsafe operation. The design of C-E/WIS's combustor is unique in that it has been specifically designed to accommodate all the waste incineration requirements of an operating nuclear power plant. Full-scale prototype tests of the C-E/WIS have demonstrated its capability to incinerate wastes safely with the maximum reduction in volume.

Waters, R. M.; Volodzko, M.

THE IMPACT OF PVC ON WASTE INCINERATION SYSTEMS
Paper presented at American Nuclear Society Conference, Combustion Engineering, Inc., August 1983.

Governed by increasing burial costs and other adverse economic factors, more and more emphasis is being placed on finding methods to reduce volumes of power reactor wastes. Incineration is one such method.

Incinerable mixes of dry active waste can contain various quantities of polyvinyl chlorides (PVCs). These PVCs have an adverse impact on incineration processes in terms of (1) potential chloride attack on process materials and (2) reduced volume reduction factors resulting from chemical addition required for chloride neutralization. The end result is an overall system cost increase due to selections of sophisticated materials and an overall cost increase for packaging, transporting, and burying the incinerator ash product.

This paper presents Combustion Engineering, Inc.'s (C=E's) selection criteria for materials in the C-E Waste Incineration System. A critique of the impact on system volume reduction factors for a range of PVC in the waste stream is also included.

Wilke, M.; Fatho, K.

INCINERATION OF RADIOACTIVE WASTES APPLYING THE "JUELICH INCINERATION PROCESS"
Kaftanlagen Aktiengesellschaft, Heidelberg, April 1981.

Development of the Juelich incineration process started in 1969. Its purpose was to burn waste from the Juelich nuclear research plant in Germany. Today, comprehensive operating experience of several years is available, and a large number of test runs have been made on the prototype plant. The data collected permit the design of future incineration plants of different capacities and for most different waste compositions. Incineration by the Juelich process is made in two stages. In the first stage, the waste is thermally treated by pyrolysis. Only in the second stage are these pyrolysis products burned. Both energy and waste flows are routed through the incineration plant in a parallel direction. The temperatures in the treatment chamber range between 100 and 800=C. Since the maximum temperatures reached during pyrolysis are about 800=C, this process stage is to be considered as medium-temperature pyrolysis. In the thermal treatment chamber, the waste is initially dried at rising temperatures and then degassed and/or gasified and coked. The pyrolysis products are then completely burned in the combustion chamber at about 900=C using a controlled air supply.

# APPENDIX A

## Specific Incinerator Designs

### A.1 Controlled Air Incinerator

Controlled air incinerators have been and are being used extensively for incinerating commercial, industrial and municipal wastes. These incinerators are multi-chambered in which two stage combustion takes place. Solid fuel combustions in the primary chamber is followed by gaseous phase combustion in the secondary chamber. The most frequently used configuration consists of two stacked, horizontal cylinders. Smaller units may use the stack for secondary combustion. Most designs have multiple natural gas burners for maintaining temperature control in the chambers.

### A.2 Fluidized Bed Incinerators

The basic fluidized bed incinerator consist of a vessel which contains a bed of inert granular particles. Blower driven air enters at the bottom and proceeds vertically through the bed agitating or fluidizing it and causing it to behave as a dense liquid mass. Waste are injected by various means into the bed where combustion takes place.

Typical bed temperatures range from 1400 - 1600 F. Solid materials remain in the bed until they have become small and light enough to be carried off with the flue gas as a particulate. As with most incineration techniques, fluidized bed combustion may generate particulates which may require filtration, scrubbing or precipitation prior to release.

## A.3 Molten Salt Incinerator

The basic molten salt incinerator involves the injection of waste below the surface of a molten salt bath, typically 90% sodium carbonate and 10% sodium sulfate. Pyrolysis of the feed material occurs first with the pyrolyzed gases being combusted in the reactor or in subsequent afterburners. Sulfur oxides react with the salt to form sodium sulfate, and hydrogen chloride reacts to form sodium chloride. Particulates are entrapped in the salt. A variety of auxiliary fuels may be used.

## A.4 Multiple Hearth Incinerators

The basic furnace is a refractory lined steel shell with vertically stacked refractory hearths. A rotating central shaft equipped with horizontal plows push the waste material across the face of each hearth to drop holes connecting to the next hearth. The wastes continue to pass through each hearth until residue ash falls to the furnace floor. Air

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and combustion products flow counter currently to the feed from the bottom to the top of the combustion chamber. Gases normally require scrubbing or filtration prior to release.

## A.5 Rotary Kiln Incinerator

The rotary kiln incinerator consist of a cylindrical, horizontal, refractory lined shell which is mounted at a slight incline. Rotation of the shell causes mixing of wastes with combustion air, thus improving efficiency. Combustion temperatures vary according to the characteristics of the material being incinerated. Residence time varies from several seconds to hours, depending on the wastes. Most rotary kiln installations are equipped with scrubber emission controls.

## A.6 Slagging Pyrolysis Incinerator

The slagging pyrolysis incinerator consist of a vertical chamber in which wastes are inserted through the top. As the material moves down the chamber, it passes through a drying zone, a pyrolysis zone and finally into a combustion and melting zone. Preheated air is inserted into the hearth through nozzles. The slag is drawn off through a runner into a quenching tank. The gases driven off in the pyrolysis zone are removed in an afterburner and directed to the secondary chamber for complete oxidation.

## A.7 Acid Digestion Unit

In acid digestion units, shredded wastes are discharged onto a shallow tray where they are contacted with nitric acid and recirculation sulfuric acid which is air lifted from a heated reservoir. Solids which accumulate in the system are removed by periodic transfer of a portion of the acid slurry to a separate evaporator pot. The sulfuric acid is evaporated and returned to the digester for reuse. Combustible wastes are converted to gaseous products and sulfate residues by digestions in $H_2SO_4$ in the presence of nitric acid oxidant.

# APPENDIX B

## Sample Regulatory Guidance for Preparation of Applications for Laboratory and Industrial Use of Small Quantities of Radioactive Material

Revision 1
May 1985

WASHINGTON STATE DEPARTMENT OF SOCIAL AND HEALTH SERVICES
DIVISION OF HEALTH, RADIATION CONTROL SECTION

# REGULATORY GUIDE 10.7

# GUIDE FOR THE PREPARATION OF APPLICATIONS FOR LICENSES FOR LABORATORY AND INDUSTRIAL USE OF SMALL QUANTITIES OF RADIOACTIVE MATERIAL

## 1. INTRODUCTION

This guide describes the type of information required by the department to evaluate an application for a specific license for laboratories and industries using millicurie quantities of radioactive material. This type of license is provided for under Chapter 402-19 WAC, "Requirements of General Applicability to Licensing of Radioactive Material."

WAC 402-10-010, "Statement of Philosophy," states that "...persons engaged in activities under licenses issued by the Washington State Department of Social and Health Services pursuant to the Atomic Energy Act of 1954, as amended, shall, in addition to complying with the requirements set forth in chapter 402-24 WAC, make every reasonable effort to maintain radiation exposures, and releases of radioactive materials in effluents to unrestricted areas, as low as is reasonably achievable" (ALARA). Regulatory Guide 8.10, "Operating Philosophy for Maintaining Occupational Radiation Exposures As Low As Is Reasonably Achievable," provides the department position on this important subject. License applicants should give consideration to the ALARA philosophy, as described in Regulatory Guide 8.10, in the development of plans for work with licensed radioactive materials.

## 2. LICENSE FEES

An application fee is required for radioactive material licenses. Refer to WAC 440-44-057, "License Fees For Radioactive Materials," to determine the amount of fee that must accompany the application. Review of the application will not begin until the proper fee is received by Washington State Department of Social and Health Services, Division of Health, Administrative Support Section, M.S. ET-26, Olympia, Washington 98504.

## 3. FILING AN APPLICATION

Complete Form RHF-1LI, "Application For Radioactive Material License--Laboratory-Industrial." All items on the application form should be completed in sufficient detail for Radiation Control to determine that the applicant's equipment, facilities, and radiation protection program are adequate to protect health and minimize danger to life and property.

Since the space provided on Form RHF-1LI is limited, the applicant should append additional sheets to provide complete information. Each separate sheet or document submitted with the application should be identified by a heading indicating the appropriate item number (on Form RHF-1LI) and its purpose (e.g., radiation safety instructions).

The application should be completed in triplicate. The original and one copy should be mailed to Washington State Department of Social and Health Services, Division of Health, Administrative Support Section, Mail Stop ET-26, Olympia, Washington 98504. One copy of the application, with all attachments, should be retained by the applicant since the license will require, as a condition, that the licensee follow the statements and representations set forth in the application and any supplement to it.

## 4. CONTENTS OF AN APPLICATION

Most items of Form RHF-1LI are self-explanatory. The following comments apply to the indicated numbered items of the form.

Item 1a. Name and Mailing Address. Specify the applicant corporation or other legal entity by name and mailing address of principal office. Individuals should be designated as the applicant only if the use of the radioactive material is not connected with the individual's employment with a corporation or other entity. If the applicant is an individual, the individual should be specifed by full name and address, including state and zip code.

Item 1b. Street Address. Specify the street address of the location of use if the address differs from the one given in Item 1a. If use is to be at more than one location, the specific address of each should be given. Describe the extent of use and the facilities and equipment at each location. A post office box address is not acceptable. No license can be issued unless the applicant lists an in-state permanent address, even if all uses of radioactive materials will be at temporary job-sites.

Item 4a. Authorized Users. Specify the names of the persons who will directly supervise the use of radioactive material or who will use radioactive material without supervision.

Item 4b. Training and Experience. Complete RHF-1LI Appendix A for the Radiation Safety Officer and each authorized user, unless this information has been previously submitted as part of a license application. Designate which license the information was filed under.

The qualifications, training, and experience of each person should be commensurate with the material and its use as proposed in the application. The amount and type of training and experience with radiation and radioactive materials required to support a determination of adequacy by the department will vary markedly with certain factors.

If other persons such as technical assistants and laboratory workers will use radioactive materials in the absence of persons specified above, the specification of the training of such personnel should include (a) instruction in radiation safety including topics covered and by whom taught, (b) on-the-job training in use of radioactiave materials, and (c) determination of competency to work with the presence of supervisory personnel.

The use of microcurie quantities of nonvolatile radioactive materials by a person with a minimum of training and experience under controlled conditions may be justified provided it is done under the surveillance of a radiation protection officer. Such minimum training and experience may consist of a few hours of training and experience in the use of one or more radioactive materials similar to the use proposed in the application under the supervision and tutorship of a licensed user.

Persons using millicurie quantities of a number of radionuclides for general laboratory tracer work under unspecified conditions should have more extensive training and experience and, depending on the exact nature of the proposed program of use of radionuclides, may need to have completed formal course work at the college or university level covering the areas listed in RHF-1LI Appendix A.

The use of larger quantities of material (approaching a curie) under conditions where a potential exists for significant loss and ingestion, inhalation, or absorption of the radioactive material by those working with the material is normally done under carefully controlled conditons using specialized equipment. A person who is to use radioactive materials independently under these conditions should not only have a background of formal training in all areas described in RHF-1LI Appendix A but should also have extensive experience working with radioactive material and a thorough working knowledge of the equipment required to handle the material safely.

Item 5a. Radiation Safety Officer. Specify the name of the person who will be designated as the radiation safety officer or radiation protection officer. This person will be responsible for implementing the radiation safety program and must therefore be readily available to the users in case of difficulty. He must be trained and experienced in radiation protection and in the use and handling of radioactive materials. In a small program not requiring a full-time radiation protection officer, the duties of the radiation protection officer may be assigned to one of the persons named under Item 4a of Form RHF-1LI. Note, however, that it must be established that the person acting as radiation protection officer will have the opportunity to devote sufficient time to the radiation safety aspects of the program for the use of radioactive materials.

Items 6, 7, and 8. Radioactive Material Description. Describe the radioactive material by isotope, chemical and/or physical form and activity, in millicuries or microcuries. A separate possession limit for each nuclide must be specified. Possession limits requested must cover the total anticipated inventory, including stored materials and waste, and should be commensurate with the applicant's needs and facilites for safe handling.

If the use of sealed or plated sources is contemplated, the isotope, manufacturer, and model number of each sealed or plated source must be specified.

Item 9. Device and/or Use Description. If a source will be used in a gas chromatograph, gauge, or other device, the manufacturer and model number of the device must be specified. In any case, the use to be made of the radioactive materials must be clearly described. Sufficient detail must be given to allow a determination of the potential for exposure to radiation and radioactive materials, both of those working with the materials and of the public.

Item 10. Radiation Detection Instruments. Specify for each radiation detection instrument used in the radiation safety program the manufacturer's name and model number, the number of each type of instrument available, the type of radiation detected (alpha, beta, gamma, or neutron), the sensitivity range (milliroentgens per hour or counts per minute), the window thickness in mg/cm, and the type of use. The type of use would normally be monitoring, surveying, assaying, or measuring.

Item 11. Calibration of Detection Instruments. Some programs are so small that survey instruments are not required. This is particularly true where only low energy beta isotopes are used. If the applicant does not need and does not plan to procure a radiation survey instrument, mark "No survey instruments possessed. N/A". All radiation detection instruments possessed must be calibrated. Designate the frequency of calibration. Designate whether the applicant will do instrument calibration, or whether applicant will contract with approved service agency for instrument calibration. Appendix C is provided for the convenience of the applicant as acceptable procedures for calibrating dose rate instruments. The applicant may sign and submit Appendix C or equivalent procedures for the calibration of dose rate instruments.

Other instrument systems requiring calibration. Meet the following criteria:

1. Describe the instrument calibration methods and procedures for the calibration of contamination monitoring instruments, as well as any other instruments and systems used in the radiation protection program, such as measuring instruments used to assay sealed-source leak-test samples (see Item 16), contamination samples (e.g., air samples, surface "wipe" samples), and bioassay samples (see Item 13).

2. An adequate calibration of instruments usually cannot be performed with built-in check sources. Such check sources are, however, ideal for instrument standardization. Electronic calibrations that do not involve a source of radiation are generally not adequate to determine the proper functioning and response of all components of an instrument.

3. Daily or other frequent checks (standardization) of contamination monitoring instruments should be performed. Additionally, a determination should be made annually and after each repair or battery change to verify that the minimum sensitivity of the instrument is appropriate for energies of the radionuclides of concern. This determination should be made using sources which are traceable to NBS.

4. Description of calibration procedures must include, as a minimum:

a. The name of the manufacturer and model number of each of the standards to be used,

b. The nuclide and quantity of radioactive material contained in each of the standard sources,

c. A statement of the accuracy of each of the standard sources. The source accuracy should be, as a minimum, ± 5 percent of the stated value and traceable to a primary standard, such as that maintained by the National Bureau of Standards.

d. Step-by-step calibration procedures and, if appropriate, associated radiation safety procedures, and

e. The name and pertinent experience of each person who will perform the instrument calibrations.

Item 12. Personnel Monitoring. WAC 402-24-070 specifies when personnel monitoring is required. If film badge or thermoluminescent dosimteters (TLD) will be used, specify the name of the organization furnishing the dosimetry service and the frequency for changing badges, dosimeters, etc. If pocket chambers or pocket dosimeters will be used, specify the useful range of the device, in milliroentgens, the frequency of reading, and the procedures for maintaining and calibrating the devices.

If personnel monitoring will not be used, submit calculations or documentations from radiation surveys demonstrating that it is unlikely that any individual will receive a dose equal to or greater than that indicated in WAC 402-24.

Item 13. Bioassay Program. Show that the need for bioassays has been thoroughly considered and establish the adequacy of the proposed bioassay program in relation to the proposed program of use of radioactive material. Consult Washington State Department of Social and Health Services, Division of Health, Radiation Control Section, Regulatory Guide 8.9, "Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program," Regulatory Guide 8.20, "Bioassay Program Criteria for I-125 and I-131," and Regulatory Guide 8.99, "Bioassay Requirements for Tritium" for further guidance in establishing a bioassay program.

Specify and describe in detail the criteria to be used in determining the need for bioassays, the type and frequency of bioassays that will be performed, and the bioassay procedures. Provide the name and address of the service agency if a commercial bioassay service is to be used.

Bioassays may not be substituted for other elements of a safety program such as air monitoring and dispersion control (hoods, glove boxes, etc.) and for well-thought-out and well-executed handling procedures.

Item 14. Facilities. Attach to the application a diagram and description of the facilities, storage areas, and equipment. If there is more than one location of use, describe in detail the facilities and equipment for each site. The proposed facilities and equipment for each operation to be conducted should be adequate to protect health and minimize danger to life and property. In describing available facilities and equipment, include the following as appropriate:

a. Physical plant, laboratory, or working area facilities. Describe fume hoods, glove boxes, waste receptacles, special sinks, ventilation and containment systems, effluent filter systems, and all processing, work, and protective clothing change areas.

Submit a drawing or sketch showing the location of all such equipment and the relationship of areas where radioactive materials will be handled to unrestricted areas where radioactive materials will not be handled. In those programs where radioactive material may become airborne or may be included in airborne effluents, include a schematic description of the ventilation system in the drawing or sketch annotated to show airflow rates, differential pressures, filtration and other effluent treatment equipment and air and effluent monitoring instruments. Make the drawings or sketches to scale and include the dimensions on each drawing or sketch. Label each drawing or sketch to specify the location of the facilities and equipment depicted with respect to the address(es) given in Item 1b of Form RHR-1LI.

b. Containers, devices, protective clothing, auxiliary shielding, general laboratory equipment, air sampling equipment, etc., actually employed in the daily use of material. Describe special provisions for shielding and containment to minimize personnel exposure. Storage containers and facilities should provide both shielding and security for materials.

c. The number, type, and length of remote handling devices.

d. Follow the provisions of WAC 402-24-030 and submit appropriate information if respiratory protective equipment will be used to limit the inhalation of airborne radioactive material.

Item 15. Survey Program. Department regulations require that surveys be made to determine if radiation hazards exist in a facility in which radioactive materials are used or stored (see WAC 402-24-085). Surveys include the evaluation of external exposure to personnel, concentrations of airborne radioactive material in the facility, and radioactive effluents from the facility. Although a theoretical calculation is often used to demonstrate compliance with regulations regarding airborne or external radition, it cannot always be used in lieu of a physical survey.

Except for those cases where sources of radiation and radioactive material are well known and accurately and precisely controlled, it will usually be necessary that a physical survey be made with appropriate detection and measurement instruments to determine the nature and extent of radiation and radioactive material or, as a minimum, confirm the results of a theoretical determination.

Appendix D is included as a convenience to the applicant in establishing an acceptable survey program. If the applicant does not wish to utilize the Appendix D standard survey program, the applicant must submit a survey program including the following surveys:

(1) In laboratory or plant areas (e.g., checking for contamination on bench tops, handling and storage equipment, clothing, hands).

(2) While work is being done with radiation or radioactive materials (e.g., breathing zone air surveys; general air surveys; personnel exposure measurements, including eyes and extremities).

(3) In areas associated with disposal or release of radioactive materials (e.g., checking disposal containers and disposal sites; liquid, gas, and solid effluents, filters and filter-duct systems).

The frequency of surveys will depend on the nature of the radioactive materials and their use. However, surveys should be performed prior to the use of radioactive materials in order to establish a baseline. The surveys should be repeated when radioactive materials are present and changes in the use, location, or control of radioactive materials occur.

For operations involving radioactive materials in gas, liquid, or finely divided forms, the survey program must be designed to monitor the adequacy of containment and control of the materials involved. The program must include air sampling, monitoring of effluents, and surveys to evaluate contamination of personnel, facilities, and equipment. Physical effluent measurements are essential to determine compliance with WAC 402-24-220 Appendix A.

The description of an air sampling program must include the area where samples will be taken, the frequency of sampling, and the location of the sampler with respect to workers' breathing zones. Assays performed to evaluate air samples and the methods used to relate results to actual personnel exposures must also be described.

The effluent monitoring program for releases to unrestricted areas should encompass all airborne and liquid radioactive material releases. Theoretical evaluations should be supplemented by stack monitoring, water sampling, and other environmental monitoring appropriate for the planned and potential releases.

For operations involving only sealed sources, such as fixed gauges, external radiation surveys must be made for both storage/off and use/on configurations at time of installation. Supplemental surveys should be performed following any changes in operation, shielding, or use.

The types, methods, and frequency of surveys should be described in the application. Guidance may be obtained from the National Council on Radiation Protection Report No. 10, "Radiological Monitoring Methods and Instruments," and the International Atomic Energy Agency's Technical Report Series No. 120, "Monitoring of Radioactive Contamination on Surfaces."

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Copies may be obtained from NCRP Publications, P.O. Box 4867, Washington, D.C. 20008.

Copies may be obtained from UNIPUB Inc., P.O. Box 433, New York, N.Y. 100016.

Item 16. Leak Test Program. Sealed sources containing more than 100 microcuries of a beta or gamma emitter or more than 10 microcuries of an alpha emitter must be leak tested at 6-month intervals. Leak testing of alpha-particle-emitting sources containing more than 10 microcuries of an alpha emitter is required at 3-month intervals. If a commercial firm is to perform the leak tests, the name, address, and license number of the firm should be submitted. If the tests are to be performed using a commercial "kit," the name of the manufacturer or distributor and processor of the kit should be given. If the applicant intends to perform his own leak tests without the use of a commercial kit, the following information must be submitted:

(1) Qualifications of personnel who will perform the leak test,

(2) Procedures and materials to be used in taking test samples,

(3) The type, manufacturer's name, model number, and radiation detection and measurement characteristics of the instrument to be used for assay of test samples,

(4) Instrument calibration procedures, including calibration source characteristics, make, and model number, and

(5) The method, including a sample calculation, to be used to convert instrument readings to units of activity, e.g., microcuries.

Item 17. Records Management Program. Complete and attach Appendix E (which defines required records for laboratory and industrial use of small quantities of radioactive material). Attach to application a sample of each record form used in the radiation safety program.

Item 18. Instructions of Personnel. Appendices F and G are provided as a convenience to the applicant in establishing an acceptable training program for radiological and non-radiological workers. If the applicant does not wish to utilize these standard appendices, an equivalent description of the personnel training program must be submitted with the application as an attachment. The instructions must include, but not necessarily be limited to:

(1) The availability, selection, and use of laboratory apparel and safety-related equipment and devices (e.g., laboratory coats, gloves, and remote pipetting devices).

(2) Limitations and conditions required for handling liquid or uncontained (unencapsulated, dispersible, or volatile) radioactive materials and special laboratory equipment required for working with these types of materials. For example, the instructions must explain when operations with materials must be confined to a radiochemical fume hood or glove box and must specify the use of appropriate shielding and remote handling equipment when energetic beta- or gamma-emitting materials are to be used.

(3) The performance of radiation survey and monitoring procedures for each area in which radioactive materials are to be used.

(4) Safety precautions required for the movement of radioactive materials between buildings, rooms, and areas within rooms.

(5) Safety requirements for storage of radioactive materials, including labeling of containers of radioactive materials and posting and securing areas where radioactive materials are to be stored. This should include the storage of contaminated laboratory equipment such as glassware.

(6) Requirements for posting of areas in which radioactive materials are used.

(7) The availability and use of personnel monitoring devices, including the recording of radiation exposures and the procedures required for the processing of personnel monitoring devices such as thermoluminescent dosimeters and film badges in order to obtain personnel monitoring results.

(8) Waste disposal procedures required, including limitations on the disposal of liquid or other dispersible waste to the sanitary sewer and procedures for the collection, storage, and disposal of other wastes.

(9) The maintenance of appropriate records as required by WAC 402-24 and WAC 402-19.

(10) The requirements for and the method of performing or having appropriate sealed-source leak tests performed.

(11) Good radiation safety practices, including the control of contamination, specification of acceptable removable and fixed contamination levels for both restricted and unrestricted areas, prohibition of smoking and the consumption of food or beverages in areas where radioactive materials may be used, and prohibition of the frequent transfer of potentially contaminated equipment between potentially contaminated areas and unrestricted areas.

(12) The use of radioactive material in animals. If radioactive materials will be used in animals, instructions concerning such use should be prepared and submitted with the license application. Such instructions should include (a) specification of the facilities to be used to house the animals, (b) instructions to be provided to animal caretakers for handling animals, animal wastes, and carcasses, (c) instructions to appropriate personnel for cleaning and decontaminating animal cages, and (d) methods to be used to ensure that animal rooms will be locked or otherwise secured unless attended by authorized users of radioactive materials. A description of animal handling and housing facilities should be included under Item 23 of Form RHF-1LI.

(13) Emergency procedures. These instructions must be addressed to all personnel in all laboratory or facility areas where radioactive materials will be used and must cover actions to be taken in case of accidents involving radioactive materials such as spills, fires, release or loss of material, or accidental contamination of personnel. Specifically, these instructions must (a) specify immediate actions to be taken in order to prevent or limit the contamination of personnel and areas, e.g., the shutting down of ventilation equipment, evacuation of contaminated and potentially contaminated areas, con-

tainment of any spills of radioactive material, (b) give the telephone numbers of individuals to be notified in case of emergency, and (c) instruct personnel in proper entry, decontamination, and recovery operations for contaminated facilities. (Note: Only properly trained individuals should attempt decontamination and recovery operations.)

(14) Requirements and procedures for receiving and opening packages (see WAC 402-24-125 and RHF-1LI Appendix J).

Item 19. Waste Disposal. Appendix H is included for the convenience of the license applicant in establishing an adequate radioactive waste disposal program. If the applicant does not wish to utilize Appendix H, the applicant's procedures for disposing of radioactive waste must be described in an attachment to the application. Under department regulations, a licensee may dispose of waste in the following ways:

a. Transfer to a person properly licensed to receive such waste in conformance with WAC 402-24-130. The name of the firm (which should be contacted in advance to determine any limitations that the firm may have on acceptance of waste) should be given.

b. Release into a sanitary sewer in conformance with WAC 402-24-140. Depending on water usage, releases of up to 1 curie per year are permitted.

c. Release into air or water in concentrations in conformance with WAC 402-24-050. Possible exposure to persons offsite limits the amount that may be released.

d. Other methods specifically approved by the department pursuant to WAC 402-24-135.

Item 20. Emergency Procedures. Appendix I is included as a guide to the applicant in establishing acceptable emergency procedures. If the applicant does not wish to utilize Appendix I, then detailed emergency procedures equivalent to Appendix I must be submitted as an attachment to the license application. For guidance in composing acceptable emergency procedures see Appendix I and also Item 18 paragraph (13) of this Regulatory Guide.

Item 21. Ordering and Receiving Packages. Appendix J is an example of acceptable procedures for ordering and receiving packages. If the applicant does not wish to utilize Appendix J, the applicant must submit equivalent ordering and receiving procedures as an attachment to the license application. For guidance in composing such procedures, consult Appendix J and WAC 402-24-125.

Item 22. Opening Packages. Appendix K is included for the convenience of the applicant in establishing acceptable procedures for opening packages. If the applicant does not wish to utilize Appendix K, the applicant must submit equivalent opening procedures as an attachment to the license application. For guidance in composing such procedures, consult Appendix K and WAC 402-24-125.

Item 23. Animal Use. If no animal use is planned, check "Not Applicable" under Item 23 in Form RHF-1LI. If animal use is anticipated or planned, submit detailed radiation safety procedures (including waste disposal) as an attachment to the license application. For guidance in composing such procedures, consult WAC 402-24.

Item 24. License Fee Required. Consult WAC 440-44-057 for determination of required license fee. List fee category in Subitem 24a. Enter license fee in Subitem 24b. All new applications require a license fee. Review of license application cannot commence until license fee has been received by Department of Social and Health Services, Division of Health, Administrative Support Section, ET-26, Olympia, Washington 98504.

Item 25. Certificate. Item 25 must be completed on all applications. The form must be dated and signed by the corporate management (not the Radiation Safety Officer unless the management has filed with the department a statement authorizing the RSO to sign all applications and radiation safety program commitments).

## 5. AMENDMENTS TO LICENSES

Licensees are required to conduct their programs in accordance with statements, representations, and procedures contained in the license application and supportive documents. The license must therefore be amended if the licensee plans to make any changes in facilities, equipment (including monitoring and survey instruments), procedures, personnel, or radioactive material to be used.

Applications for license amendments may be filed either on the application form or in letter form, and must be signed by an appropriate corporate official. The applications should identify the license by number and should clearly describe the exact nature of the changes, additions, or deletions. References to previously submitted information and documents should be clear and specific and should identify the pertinent information by date, page, and paragraph.

## 6. RENEWAL OF A LICENSE

An application for renewal of a license should be filed at least 30 days prior to the expiration date. This will ensure that the license does not expire until final action on the applications has been taken by the department as provided for in WAC 402-22-055.

Renewal application should be filed on Form RHF-1LI, appropriately supplemented, and should contain complete and up-to-date information about the applicant's current program.

In order to facilitate the review process, the application for renewal should be submitted without reference to previously submitted documents and information. If such references cannot be avoided, they should be clear and specific and should identify the pertinent information by date, page, and paragraph.

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**HDivision of Health**
**Radiation Control Section**

# APPLICATION FOR RADIOACTIVE MATERIAL LICENSE —LABORATORY—INDUSTRIAL

INSTRUCTIONS — Complete all items in this application for a new license or the renewal of an existing license. Use supplemental sheets where necessary. Item 25 must be completed on all applications. Mail two copies to: Washington State Department of Social and Health Services, Division of Health, Administrative Support Section, Mail Stop ET-26, Olympia, Washington 98504. Upon approval of this application, the applicant will receive a State of Washington Radioactive Material License issued in accordance with the general requirements contained in Washington State Department of Social and Health Services, Division of Health, Radiation Control Regulations, and the Washington Nuclear Energy and Radiation Control Act, Chapter 70.98 RCW.

1a. NAME AND MAILING ADDRESS OF APPLICANT (Institution, Firm, individual owner, etc.) INCLUDE ZIP CODE

1b. STREET ADDRESS(ES) AT WHICH RADIOACTIVE MATERIAL WILL BE USED (if different than 1a.) INCLUDE ZIP CODE

2. PERSON TO CONTACT REGARDING THIS APPLICATION

TELEPHONE NO.

3. THIS IS AN APPLICATION FOR: (Check appropriate item)

A. ☐ NEW LICENSE * B. ☐ AMENDMENT TO LICENSE NO. ______ C. ☐ RENEWAL * OF LICENSE NO. ______

4a. INDIVIDUAL USERS (Name of individuals who will use or directly supervise use of Radioactive Material.)

4b. TRAINING AND EXPERIENCE (Check one or more)

☐ Appendix "A" completed and attached for RSO and each USER

☐ Training Previously Filed under License # ______

5a. RADIATION SAFETY OFFICER (RSO) (Name of person designated as Radiation Safety Officer.)

5b. DUTIES OF RADIATION SAFETY OFFICER (check one)

☐ Appendix "B" Duties Attached,

or

☐ Equivalent Duties Attached

| 6. RADIOACTIVE MATERIAL (Elements and Mass number of each.) | 7. CHEMICAL AND/OR PHYSICAL FORM OR SEALED SOURCE MANUFACTURER AND MODEL NUMBER | 8. MAXIMUM QUANTITY OF EACH CHEMICAL OR ACTIVITY OF EACH SOURCE |
|---|---|---|
| A ______ | A ______ | A ______ |
| B ______ | B ______ | B ______ |
| C ______ | C ______ | C ______ |

9. DEVICE AND/OR USE DESCRIPTION (Make lettering correspond to lettering in items 6, 7, and 8 above)

| | |
|---|---|
| A. | |
| B. | |
| C. | |

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* LICENSE FEE REQUIRED (Complete item No. 24.)

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10. RADIATION DETECTION INSTRUMENTS (List Radiation Detection Instruments used in your radiation safety program.)

| MANUFACTURER | MODEL # | RANGE | DETECTS ($\alpha \beta \gamma n$) | WINDOW THICKNESS (mg cm²) | TYPE OF USE |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

11. CALIBRATION OF DETECTION INSTRUMENTS (Mandatory for all instruments possessed.)

(check one)

☐ No survey instruments possessed N/A

☐ Calibration will be done annually and after each repair

☐ Calibration will be done semi-annually and after each repair

DOSE RATE INSTRUMENT CALIBRATIONS (Check One)

☐ Applicant will do instrument calibrations

  ☐ Appendix C procedures followed and attached, or

  ☐ Equivalent procedures attached

☐ Calibration will be done by calibration service agency

Name ____________________

Address ____________________

____________________

License Number ____________________

OTHER INSTRUMENT CALIBRATIONS

☐ Calibration procedures for other than dose rate instruments attached (see Reg. Guide 10.7, Item 11)

12. PERSONNEL MONITORING (Check as appropriate)

☐ No personnel monitoring justification attached

TYPE

☐ Whole Body ☐ Extremity

  ☐ TLD ☐ TLD

  ☐ Film ☐ Film

RADIATION DETECTED

☐ Beta-Gamma

☐ Beta-Gamma-Neutron

FREQUENCY

☐ Monthly ☐ Quarterly

Name and address of Film Badge or TLD Supplier

Name ____________________

Address ____________________

____________________

☐ DIRECT READING POCKET DOSIMETER

| MANUFACTURER | MODEL # | RANGE |
|---|---|---|
| | | |
| | | |

The following dosimeter requirements will be met

☐ Dosimeters, film badges, TLD stored in cool, dry place away from radiation sources when not in use.

☐ Checked annually per WAC 402-36-120.

☐ Zeroed/charged at beginning of each shift

(Check one below)

☐ Applicant will do pocket dosimeter checks (attach methods and procedures) (WAC 402-36-120), Or

☐ Checks will be done by approved service agency

Approved Pocket Dosimeter Service Agency

Name ____________________

Address ____________________

____________________

License Number ____________________

13. BIOASSAY PROGRAM (if applicable)

☐ Bioassay program will be in accordance with Reg. Guide 8.9 (General), Reg. Guide 8.20 (I-125 and I-131), and Reg. Guide 8.32 (Tritium)

☐ Detailed bioassay program attached

14. FACILITIES

☐ Facilities and Storage Diagram Attached

☐ Facilities and equipment description attached

15. SURVEY PROGRAM

☐ Appendix D procedures signed and attached, or

☐ Equivalent survey criteria and procedures attached

16. LEAK TEST PROGRAM

(check one)

☐ Applicant will contract with approved outside consultant to do leak tests

Name ____________________

Address ____________________

____________________

☐ Applicant will do leak tests using approved leak test kit, mailing leak tests to kit manufacturer for counting.

Manufacturer name, address

Name ____________________

Address ____________________

____________________

☐ Will do own leak test including counting. Detailed procedures attached.

17. RECORDS MANAGEMENT PROGRAM

☐ Appendix E completed and attached

☐ Sample of each record form attached

18. INSTRUCTIONS TO PERSONNEL

☐ Appendix F completed and attached, or

☐ Instructions to personnel attached.

☐ Appendix G Lab Safety Rules followed, or

☐ Equivalent safety rules attached.

19. WASTE DISPOSAL

☐ Appendix H completed and attached, or

☐ Equivalent procedures attached

20. EMERGENCY PROCEDURES

☐ Appendix I completed and attached, or

☐ Equivalent procedures attached

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BEST COPY AVAILABLE

21 ORDERING AND RECEIVING PACKAGES

☐ Appendix J completed and attached, or

☐ Equivalent procedures attached

22 OPENING PACKAGES

☐ Appendix K completed and attached, or

☐ Equivalent procedures attached

23 ANIMAL USE

☐ Not Applicable

☐ Detailed radiation safety procedures attached (including waste disposal)

24 LICENSE FEE REQUIRED
(See WAC 440-44-057)

a LICENSE FEE CATEGORY ____________________

b. LICENSE FEE ENCLOSED $____________________

## ITEM 25 — CERTIFICATION

(This item must be completed by applicant)

THE APPLICANT AND ANY OFFICIAL EXECUTING THIS CERTIFICATE ON BEHALF OF THE APPLICANT NAMED IN ITEM 1, CERTIFY THAT THIS APPLICATION IS PREPARED IN CONFORMITY WITH WASHINGTON STATE DEPARTMENT OF SOCIAL AND HEALTH SERVICES, HEALTH SERVICES DIVISION RADIATION CONTROL REGULATIONS AND THAT ALL INFORMATION CONTAINED HEREIN, INCLUDING ANY SUPPLEMENTS ATTACHED HERETO, IS TRUE AND CORRECT TO THE BEST OF OUR KNOWLEDGE AND BELIEF.

____________________ (TYPE OR PRINT NAME OF CERTIFYING OFFICIAL)

BY ____________________ (SIGNATURE)

____________________ (TITLE OF CERTIFYING OFFICIAL)

DATE ____________________

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RHF-1LI APPENDIX A

TRAINING AND EXPERIENCE
AUTHORIZED USER OR RADIATION SAFETY OFFICER
(Use supplemental sheets if necessary.)

1. NAME OF APPLICANT

2. TRAINING RECEIVED IN BASIC RADIOISOTOPE HANDLING TECHNIQUES

| TYPE OF TRAINING | WHERE TRAINED | DURATION OF TRAINING | FORMAL COURSE | ON THE JOB |
|---|---|---|---|---|
| a. Principles and practices of radiation protection | | | YES NO | YES NO |
| b. Radioactivity measurement standardization and monitoring techniques and instruments | | | YES NO | YES NO |
| c. Mathematics and calculations basic to the use and measurement of radioactivity | | | YES NO | YES NO |
| d. Biological effects of radiation | | | YES NO | YES NO |

3. EXPERIENCE WITH RADIATION (Actual use of radioisotopes)

| ISOTOPE | MAXIMUM AMOUNT | WHERE EXPERIENCE WAS GAINED | DURATION OF EXPERIENCE | TYPE OF USE |
|---|---|---|---|---|
| | | | | |

## RESUME OF RADIATION WORK EXPERIENCE

| DATES OF EMPLOYMENT | EMPLOYER ADDRESS | JOB TITLE DUTIES |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

## RHI-1LI APPENDIX B

## DUTIES OF THE RADIATION SAFETY OFFICER

1. Make sure that all uses of radiation are conducted safely, adhere to the conditions of the license and license applicatioin, and result in exposures to personnel which are as low as reasonably achievable (ALARA).

2. Act as liaison agent with regulatory authorities, be available for assistance in inspection and audits, and notify the department:

   A. In writing before making any change which would render the Application for Radioactive Materials License, Radioactive Materials License, Application for Registration (of radiation producing machines), or Notice of Registration no longer accurate.

   B. Immediately in the event of any radiation accident or incident (including high dosimeter reading).

   C. Within 5 days of any positive leak test result of a sealed source.

   D. Within 30 days in a report stating remedial action taken after accident or incident.

3. Be familiar with all applicable regulations and regulatory guides, and assure that license applications are properly filled out and are submitted on time.

4. Make sure all surveys, calibrations, and leak tests are performed on time.

5. Establish and maintain record systems as applicable for radiation area surveys, wipe tests, leak tests, calibration of instruments, and personnel dosimetry reports.

6. If dosimetry is required, advise individual radiation workers of each high exposure report, and conduct a survey to determine the cause of all overexposures so as to preclude reoccurrence. Perform a quarterly review of occupational exposure to authorized users and workers to determine that the exposures are within the limits established for the ALARA program. Annually apprise each radiation employee of annual accrued dose.

7. Assure that individuals working with radiation have appropriate protective devices, including shielding, ventilation, clothing, gloves, remote handling equipment (where necessary), and facilities which aid in keeping exposures As Low As Reasonably Achievable (ALARA).

8. Procure and maintain an adequate number of operable and properly calibrated radiation survey instruments, of the appropriate range and type, and properly calibrated counting equipment (if applicant will assay contamination and leak tests).

9. Develop and maintain up-to-date operating and emergency procedures.

10. Perform, or cause to be performed, quarterly inventory of all sealed sources received or possessed.

11. Post conspicuously "Notice to Employees" RHI-3 and notices of items of noncompliance resulting from department inspections.

12. Supply employers of terminated radiation personnel with radiation exposure records as required by regulation.

13. Establish and cause to be maintained inventory control of radioisotopes, making sure inventory never exceeds amounts licensed.

14. Keep, or cause to be kept, records of receipts of incoming isotopes and surveys of incoming and outgoing shipments.

15. Make sure that all incoming and outgoing radioactive shipments are properly packaged and labeled according to DOT requirements, and that shipments are accompanied by proper shipping papers.

16. Assure that radioactive materials are disposed of properly, and that records are maintained of all radioactive wastes disposed.

17. Perform an annual review of radiation safety program for adherence to ALARA concepts. Make sure that the safety program is followed by all workers dealing with radioactive materials. Investigate any deviation from the program, and take any remedial action necessary.

18. Schedule briefings and educational sessions to inform workers of radiation safety rules and procedures: 1) for all new personnel, 2) with each change in license condition or safety program, and 3) annually in a refresher course for all personnel. This includes instruction in the ALARA program and philosophy.

19. Apprise and inform management of radiation safety status and their responsibilities in maintaining an adequate radiation safety program.

20. Take charge in all emergency situations (spills, or release of radioactive material, etc.) to make sure correct emergency decontamination and protection procedures are carried out. Also evaluate the situation that led to the emergency, to reduce the chance of further problems.

21. Assure that radioactive materials are used only by individuals authorized by the license.

22. Assure that radioactive materials are properly secured against unauthorized removal.

The RSO should have some formal training in radiological health (i.e., college level or its equivalent) and should have specific experience in radiation protection with the types, quantities, and use of the radioactive material to be used under the license.

Approved by______________________________ Date____________________

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## RHF-1L1 APPENDIX C

## CALIBRATION OF DOSE RATE INSTRUMENTS

A. Calibration of survey meters shall be performed with radionuclide sources.

1. The sources shall approximate point sources.
2. The source activities or exposure rates at given distances shall be traceable by documented measurements to a standard source certified within five percent accuracy to the U.S. National Bureau of Standards (NBS) calibrations.
3. The frequency shall be at least annually and after servicing.
4. Each scale of the instrument shall be calibrated at least at two points located at approximately 1/3 and 2/3 of full scale.
5. The exposure rate measured by the instrument shall differ from the true exposure rate by less than 10 percent at the two points on each scale (read appropriate section of the instrument manual to determine how to make necessary adjustments to bring instrument into calibration). Readings within ± 20 percent will be considered acceptable if a calibration chart, graph, or response factor is prepared, attached to the instrument, and used to interpret meter readings to within 10 percent for radiation protection purposes.

NOTE:

Sources of Cs-137, Ra-226, or Co-60[*] are appropriate for use in calibrations. Since these sources emit rather high-energy photons, they are not suitable for low-energy calibrations that may be required under special circumstances (see Item C below). The activity of the calibration standard should be sufficient to calibrate the survey meters on each scale to be used for radiation protection purposes. Scales up to 1 R/hr should be calibrated, but higher-range scales above 1 R/hr need not be calibrated when they will not be needed for radiation protection surveys. If there are higher ranges, they should at least be checked for operation and approximately correct response to radiation. Otherwise, a cautionary note that they have not been checked should be placed on the instrument.

---

[*] Minimum activities of typical sources are 85 mCi of Cs-137, 21 mCi of Co-60, and 34 mCi of RA-226 (to give at least 700 mR/hr at 20 cm).

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B. A reference check source of long half-life, e.g., Cs-137 or Ra D and E, shall also be read at the time of the above calibration or as soon as the instrument is received from a calibration laboratory. The readings shall be taken with the check source placed in specific geometry relative to the detector. A reading of this reference check source should be taken:

1. Before each use and also after each survey to ensure that the instrument was operational during the survey.

2. After each maintenance and/or battery change.

3. At least quarterly.

   If any reading with the same geometry is not within ± 20 percent of the reading measured immediately after calibration, the instrument should be recalibrated (see Item A).

C. Calibration source energies must correspond to energies of radioactive materials to be detected if instrument response is energy dependent.

The calibration may be done either:

1. As in Item A above with calibrated standards of radionuclides at or near the desired energies, or

2. As a relative intercomparison with an energy-independent instrument and uncalibrated radionuclides.

Alternatively, the manufacturer's energy response curve(s) may be used to correct instrument readings appropriately when lower-energy radiation is monitored.

D. Records of the above Items A, B-2, B-3, and C must be maintained.

E. Use of Inverse Square Law and Radioactive Decay Law

1. A calibrated source will have a calibration certificate giving its exposure rate at a given distance, or its activity, measured on a specified date by the manufacturer or NBS.

   a. The Inverse Square Law may be used with any point source to calculate the exposure rate at other distances.

   b. The Radioactive Decay Law may be used to calculate the exposure rates or source activities at times other than the calibration date.

## 2. Inverse Square Law

Consider a "point"* source of radiation at position S, as shown in Figure C-1. Then, the relationship between exposure rates $R_1$ and $R_2$ at detector positions $P_1$ and $P_2$, which are at distances $D_1$ and $D_2$ and S, respectively, is given by the following equation:

$$R_2 = \frac{D_1^2 \times R_1}{D_2^2}$$

Where $R_1$ and $R_2$ are exposure rates in the same units (e.g., mR/hr, R/hr) and $D_1$ and $D_2$ are the distances in Figure D-1 in the same units (e.g., m, cm, ft).

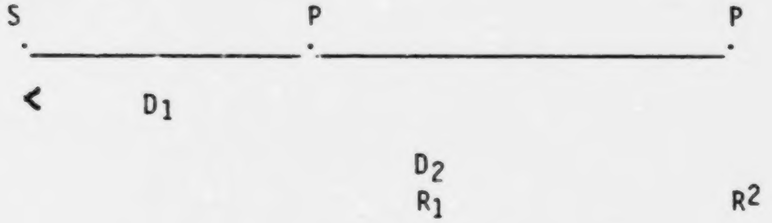

FIGURE C-1

## 3. Radioactive Decay Law

Exposure rate t units of time after specified calibaration date

$$R_t = R_o \times e^{\frac{0.693}{T_{1/2}} \times t}$$

Where

| | |
|---|---|
| $R_o$ and $R_t$ | are in the same units (e.g., mR/hr or R/hr) |
| $R_o$ | is exposure rate on the specified calibaration date. |
| $R_t$ | is exposure rate t units of time later. |
| $T_{1/2}$ and t | are in the same units (years, months, days, etc.) |
| $T_{1/2}$ | is radionuclide half-life. |
| t | is number of units of time elapsed between calibration and present time. |

---

* A source may be considered a "point" source when the source and the radiation detector are small, in any dimension, compared to the distances at which radiation is to be measured. The center of the detector should be at distances $D_1$ or $D_2$ as shown in Figure C-1.

4. Example: Source output is given by calibration certificates as 100 mR/hr at 1 foot on March 10, 1975. Radionuclide half-life is 5.27 years.

Questions: What is the output at 3 feet on March 10, 1977 (2.0 years)?

a. Output at 1 foot, 2.0 years after calibration date:

R = 100 mR/hr x e

= 100 x 0.77 = 77 mR/hr at
1 foot on March 10, 1977.

b. Output at 3 feet, 2.0 years after calibration date:

R = __________ x 77 mR/hr

= _ x 77 = 8.6 mR/hr at

3 feet, 20.0 years after calibration.

Approved by______________________________________Date__________________________

## SAMPLE FORM

## CERTIFICATE OF INSTRUMENT CALIBRATION

For:

Instrument:

Manufacturer________________________________________

Type________________________________________

Model No.________________________________________

Serial No.________________________________________

Calibration Data:

| Scale | Exposure Rate (mR/hr) | Instrument Reading (mR/hr) | Exposure Rate (mR/hr) | Instrument Reading (mR/hr) | Exposure Rate (mR/hr) | Instrument Reading (mR/hr) |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

Comments:

Calibration Source:

| Nuclide | Activity or Exposure Rate at Specified Distance | Accuracy |
|---|---|---|
| | | |

Calibrated by____________________________Date________________

## [illegible]-111 APPENDIX D

## STANDARD SURVEY PROGRAM (NON-CONTAINED SOURCES)

1. Clothing, hands, and all primary work areas (except as in 2 below) shall be surveyed daily with an appropriate low-range survey meter and decontaminated if necessary. For low energy beta emitters, appropriate wipe samples shall be taken in lieu of direct measurement.

2. Laboratory areas where only small quantities of radioactive materials are used (less than 10 microcuries of I-125 or I-131 or 100 microcuries of other non-special nuclear material or source material isotopes) will be surveyed monthly.

3. Waste storage areas and all other laboratory areas will be surveyed weekly.

4. The weekly and monthly surveys will consist of:

    a. A measurement of radiation levels with a survey meter sufficiently sensitive to detect 0.05 mR/hr.

    b. A series of wipe tests to measure contamination levels. The method for performing wipe tests will be sufficiently sensitive to detect 200 dpm per 100 cm for the contaminant involved. Wipes of elution and preparation areas or other "high background" areas will be removed to a low background area for measurement.

5. A permanent record will be kept of all survey results, including negative results. The record will include:

    a. Location, date, and identification of equipment used, including the serial number and pertinent counting efficiencies.

    b. Name of person conducting the survey.

    c. Drawing of area surveyed, identifying relevant features such as active storage areas, active waste areas, etc.

    d. Measured exposure rates, keyed to location on the drawing (point out rates that require corrective action).

    e. Detected contamination levels, keyed to locations on drawing.

    f. Corrective action taken in the case of contamination or excessive exposure rates, reduced contamination levels or exposure rate after corrective action, and any appropriate comments.

6. Area will be cleaned if the contamination level exceeds 200 dpm/100 cpm.

Approved by ______________________________ Date: ______________

BEST COPY AVAILABLE

## RHF-1LI APPENDIX E

## RECORDS REQUIRED FOR LABORATORY-INDUSTRIAL LICENSE

Laboratory and industrial radioactive material licensees are required to maintain a number of records. This form is designed to simplify your task of complying with the regulations in regards to record keeping. The different record requirements are listed below in the order they appear in WAC 402. It is your responsibility to develop your own records and make sure that all required records are accounted for.

Because the RHF-1LI application form is used for a wide variety of laboratory and industrial applications, ranging from small laboratories to large scale industrial uses of radioactive materials, this appendix may list a number of records which may not apply to all users. If a record described in the appendix is for some material or equipment that you will not have, write N/A in the space to the right of the record description. If the need for a particular record would arise only rarely, you need not compose a special form for that record, but may document the required information by letter or memo.

| SECTION OF WAC | TYPE OF RECORDS | FORM CODE NO. |
|---|---|---|
| 402-12-080(1) | General provisions require records of receipt, use, storage, transfer and/or disposal of radiation sources. | |
| 402-19-530(3) | Waste shipment certification to accompany each shipment of radioactive waste to the low-level radioactive waste burial site (may use department form RHF-31). | |
| 402-21-050(4)(c)(iv) | For licensee's with generally licensed gauges, maintain records of tests for leakage of radioactive material and proper operation of the on-off mechanism or indicator in compliance with WAC 402-21-050(4)(c)(ii) and (iii). | |
| 402-24-020(2)(c) | Records of employee's prior use history (may use departmental form RHF-4). | |

| | | |
|---|---|---|
| 402-24-020(2)(d) | A written evaluation of expected exposure in excess of that permitted under WAC 402-24-020(1). | ____________ |
| 402-24-060(2) | Record of leak tests. | ____________ |
| 402-24-070(2)(d) | Record of exposure circumstances of personnel monitoring device when it was not worn. | |
| 402-24-085 | Records of surveys preserved as specified in WAC 402-24-170. (this includes receipt surveys, contamination surveys, etc.) | ____________ |
| 402-24-140 | Records of disposal by release into sanitary sewerage systems proving compliance with limits in WAC 402-24-140. | ____________ |
| 402-24-170(1) | Records of radiation exposures on RHF-5 or all other forms containing all the information required by form RHF-5. | (this information is usually contained in vendor's film badge exposure reports)<br>____________ |
| 402-48-030 | Records of instructions to workers. | ____________ |

Note: Where records of surveys and monitoring are required, the records must show the units used in this part, i.e., millirem per hour for external radiation, microcuries for removable contamination, etc. It is not sufficient to just indicate that a survey was performed. The actual reading has to be recorded with location of the reading (see WAC 402-24-170(2)). The survey report should also give a numerical interpretation of background, and not state merely that the reading was less than background.

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## RHF-1LI APPENDIX F

## PERSONNEL TRAINING PROGRAM

1. The Radiation Safety Officer or (title)______________________ shall provide instruction to radiation workers. Instruction shall include, but is not limited to:

   a. General radioactive materials safety rules;

   b. Personnel monitoring program (e.g., use, exchange, storage, records, and reports);

   c. Radiation and contamination survey program;

   d. Accident, incident, and emergency procedures;

   e. Radioactive materials work procedures;

      1. ordering, receipt, and opening procedures,
      2. storage,
      3. use of radioactive materials,
      4. waste packaging and storage, and
      5. transportation procedures.

   f. Applicable state and federal rules and regulations and license conditions.

2. The Radiation Safety Officer or (title)______________________ shall provide instruction to ancillary personnel, such as clerical, janitorial, and security personnel, whose duties may require them to work in the vicinity of radioactive material. The instruction shall include, but not be limited to:

   a. All terms of the license pertinent to radiation safety.

   b. Identification of areas where radioactive material is used or stored.

   c. Potential hazards associated with radioactive material.

   d. Radiological safety procedures appropriate to their respective duties.

   e. Pertinent state and federal regulations.

   f. Rules and procedures of the license.

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g. Obligation to report unsafe conditions to the Radiation Safety Officer.

h. Appropriate response to emergencies or unsafe conditions.

i. Right to be informed of their radiation exposure and bioassay results.

j. Locations where the licensee has posted or made available notices, copies of pertinent regulations, and copies of pertinent licenses and license conditions (including applications and applicable correspondence), as required by WAC 402-48.

The Radiation Safety Officer shall verify that personnel will be properly instructed before assuming duties with, or in the vicinity of, radioactive materials, during annual refresher training, and whenever there is a significant change in duties, regulations, or the terms of the license.

Approved by____________________________________Date______________________

## RHF-1L1 APPENDIX G

## GENERAL RULES FOR SAFE USE OF RADIOACTIVE MATERIAL

☐ 1. Wear laboratory coats or other protective clothing at all times in areas where dispersible radioactive materials are used.

☐ 2. Wear disposable gloves at all times while handling dispersible radioactive materials.

☐ 3. Monitor hands and clothing for contamination after each procedure or before leaving the area.

☐ 4. Use shielding devices and/or remote tools when working with millicurie or greater quantities of radioactive materials.

☐ 5. a. Do not eat, drink, smoke, or apply cosmetics in any area where radioactive material is stored or used.

☐ b. Do not store food, drink, or personal effects with radioactive material (e.g., in refrigerator).

☐ 6. Wear personnel monitoring devices (film badge or TLD) at all times while in areas where radioactive materials are used or stored. These devices should be worn at chest or waist level. Personnel monitoring devices when not being worn to monitor occupational exposures should be stored in a designated low background area.

☐ 7. Wear TLD finger badges when manipulating millicurie or greater quantities of radioactive materials.

☐ 8. Dispose of radioactive waste only in specially designated drains or properly shielded receptacles.

☐ 9. Never pipette by mouth.

☐ 10. Survey laboratory work area for contamination after each procedure or at the end of the day. Decontaminate if necessary.

☐ 11. Confine radioactive solutions in covered containers plainly identified and labeled with name of compound, radionuclide, date, activity, and radiation level, if applicable.

☐ 12. Always transport radioactive material in shielded containers.

☐ 13. Use remote tools when handling sealed sources.

☐ 14. Leak test nuclear gauges with gauges in the locked, stored, or safe position (but only if the license authorizes you to take the leak tests).

Approved by________________________________Date____________________

* Check appropriate boxes which apply to, and you will institute at your facility.

## RHF-1L1 APPENDIX H

## WASTE DISPOSAL

Note: In view of the recent problems with shallow-land burial sites used by commercial waste disposal firms, licensees are encouraged to reduce the volume of waste sent to these facilities. Important steps in volume reduction are to segregate radioactive from nonradioactive waste, to hold short-lived radioactive waste for decay in storage, and to release certain materials into the sanitary sewer in accordance with WAC 402-24-140.

1. Liquid waste will be disposed of (check as appropriate)

   In the sanitary sewer system in accordance with WAC 402-24-140 (see also Item 5 below).

   By commercial waste disposal service (see also Item 4 below).**

   Other (specify):________________________________________

   ________________________________________

2. Other solid waste will be (check as appropriate)

   Returned to the manufacturer for disposal.

   Held for decay* until radiation levels, as measured in a low background area with a low-level survey meter and with all shielding removed, have reached background levels. All radiation labels will be removed or obliterated, and the waste will be disposed of in normal trash.

   Disposed by commercial waste disposal service (see also Item 4 below).**

   Other (specify):________________________________________

   ________________________________________

3. The commercial waste disposal service used will be

________________________________________
(Name) (City, State)

Radioactive Materials License No.________________________________________

* Be sure waste storage areas are described in Item 15 and are surveyed periodically (Item 16).

** If US Ecology waste disposal site in Richland is to be used, a Washington State site use permit is required prior to disposal. (Call (206) 753-4497 for application.)

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4. SANITARY SEWER RADIOACTIVE MATERIAL DISPOSAL CONCENTRATION CALCULATION.

(1) DETERMINE TOTAL VOLUME OF SEWAGE PER MONTH:____________________ml

(Note, the total volume of sewage may be estimated by averaging the volume as stated on a sewage bill or the volume of water used by a facility as stated on a water bill.)

USEFUL CONVERSIONS: 1 cubic foot = $2.832 \times 10^4$ ml
1 Gallon = $3.78 \times 10^3$ ml

(2) DETERMINE AVERAGE ACTIVITY FOR EACH ISOTOPE DISPOSED OF VIA THE SANITARY SEWER PER MONTH:

| | ISOTOPE | ACTIVITY (MICROCURIES PER MONTH) |
|---|---|---|
| a. | ________ | ____________ |
| b. | ________ | ____________ |
| c. | ________ | ____________ |
| d. | ________ | ____________ |
| e. | ________ | ____________ |

(3) FOR EACH ISOTOPE, DIVIDE THE ACTIVITY (MICROCURIES) BY THE MONTHLY VOLUME (ml):

| | ISOTOPE | ACTIVITY / MONTHLY VOLUME | = | AVERAGE MONTHLY CONCENTRATION |
|---|---|---|---|---|
| a. | ________ | ________uCi/________ml | = | ____________uCi/ml |
| b. | ________ | ________uCi/________ml | = | ____________uCi/ml |
| c. | ________ | ________uCi/________ml | = | ____________uCi/ml |
| d. | ________ | ________uCi/________ml | = | ____________uCi/ml |
| e. | ________ | ________uCi/________ml | = | ____________uCi/ml |

(4) TO DETERMINE COMPLIANCE WITH REGULATIONS REFER TO WAC 402-24-140 AND WAC 402-24-220, APPENDIX A.

Approved by______________________________Date____________________

## RHI-111 APPENDIX I

## EMERGENCY PROCEDURES

### MINOR SPILLS

1. NOTIFY: Notify persons in the area that a spill has occurred.

2. PREVENT THE SPREAD: Cover the spill with absorbent paper.

3. CLEAN UP: Use disposable gloves and remote handling tongs. Carefully fold the absorbent paper and pad. Insert into a plastic bag and dispose in the radioactive waste container. Also insert into the plastic bag all other contaminated materials such as disposable gloves.

4. SURVEY: With a low-range, thin-window G-M survey meter, check the area around the spill, hands, and clothing for contamination.

5. REPORT: Report incident to the Radiation Safety Officer.

### MAJOR SPILLS

1. CLEAR THE AREA: Notify all persons not involved in the spill to vacate the room.

2. PREVENT THE SPREAD: Cover the spill with absorbent pads, but do not attempt to clean it up. Confine the movement of all potentially contaminated personnel to prevent the spread.

3. SHIELD THE SOURCE: If possible, the spill should be shielded, but only if it can be done without further contamination or without significantly increasing your radiation exposure.

4. CLOSE THE ROOM: Leave the room and lock the door(s) to prevent entry.

5. CALL FOR HELP: Notify the Radiation Safety Officer immediately.

6. PERSONNEL DECONTAMINATION: Contaminated clothing should be removed and stored for further evaluation by the Radiation Safety Officer. If the spill is on the skin, flush thoroughly and then wash with mild soap and lukewarm water.

RADIATION SAFETY OFFICER________________________________

OFFICE PHONE:________________________

HOME PHONE:_________________________

## LOSS, THEFT, FIRE, EXPLOSION, OR VEHICLE ACCIDENT

FOLLOW THE PROCEDURES OUTLINED IN THE WASHINGTON STATE DEPARTMENT OF SOCIAL AND HEALTH SERVICES RADIATION EMERGENCY HANDBOOK. Principally this shall include:

1. SECURE THE AREA AROUND THE ACCIDENT. KEEP UNAUTHORIZED PERSONS AWAY. ALERT PEOPLE IN VICINITY OF THE PRESENCE OF RADIOACTIVITY AND A POSSIBLE HAZARD.

2. DO NOT LEAVE THE SITE. Send a helper or onlooker to notify the following:

   a. Radiation Safety Officer ______________________________

      Work phone:__________________Home phone________________

   b. Local Police______________________

   c. Local Fire Department where applicable____________________

3. The Radiation Safety Officer in turn must immediately notify State of Washington Radiation Emergency Response (206) 682-5327, which is

   (206) N-U-C-L-E-A-R,

   and other local authorities as indicated.

4. The radiation worker should inform emergency workers of the radiation hazard possibly existing, should help them keep the area secure, and should explain to the emergency personnel the location of the radioactive device or chemical and the extent of the possible hazard. In no case should the radiation worker leave the site until qualified experts arrive, unless, of course, the operator is seriously injured or incapacitated, and must be removed from the site by emergency personnel.

ALTERNATE NAMES AND TELEPHONE NUMBERS DESIGNATED BY RADIATION SAFETY OFFICER:

__________________________ __________________________

__________________________ __________________________

__________________________ __________________________

__________________________ __________________________

Approved by______________________________Date__________________

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May 1985

## RHI-111 APPENDIX J

## PROCEDURES FOR ORDERING AND ACCEPTING DELIVERY OF RADIOACTIVE MATERIAL

1. The Radiation Safety Officer or his/her designee will place all orders for radioactive materials and will ensure that the requested materials and quantities are authorized by the license and that possession limits are not exceeded.

2. A system for ordering and receiving radioactive materials will be established and maintained. The system will consist minimally of the following:

   a. Ordering of routinely used materials

      (1) Written records that identify the isotope, compound, activity levels, and supplier, etc., will be used.

      (2) The written records will be referenced when opening or storing radioactive shipments.

   b. Ordering of specially used materials

      (1) A written request will be obtained from the authorized user who will perform the procedure.

      (2) Persons ordering the materials will reference the authorized user's written request when placing the order. The authorized user's request will indicate isotope, compound, activity level, etc.

      (3) The authorized user's written request will be referenced when receiving, opening, or storing the radioactive material.

   c. Maintain written records for all ordering and receipt procedures.

3. During normal working hours, carriers will be instructed to deliver radioactive packages directly to the nuclear laboratory or to some other official receiving area for radioactive materials.

4. During off-duty hours, security personnel or other designated individuals will accept delivery of radioactive packages in accordance with the procedures outlined in the sample memorandum on the following page.

Approved by________________________________________ Date__________________________

## SAMPLE* MEMORANDUM

TO: Security personnel________________________________

FROM: Administrator________________________________

SUBJECT: RECEIPT OF PACKAGES CONTAINING RADIOACTIVE MATERIAL

Any packages containing radioactive material that arrive between 4:30 p.m. and 7 a.m. or on Sundays shall be signed for by the security guard on duty and be taken immediately to the nuclear laboratory. Unlock the door, place the package on top of the counter immediately to the right of the door, and relock the door.

If the package is wet or appears to be damaged, immediately contact the company Radiation Safety Officer. Ask the carrier to remain until it can be determined that neither the driver nor the delivery vehicle is contaminated.

RADIATION SAFETY OFFICER:________________________________

OFFICE PHONE:________________________________

HOME PHONE:________________________________

---

*Submit a copy of your own company's memorandum.

Approved by________________________________Date________________________

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## RHI-1L1 APPENDIX K

## PROCEDURES FOR SAFELY OPENING PACKAGES CONTAINING RADIOACTIVE MATERIAL

1. Special requirements will be followed for packages containing quantities of radioactive material in excess of the * Type A, quantity limits. They will be monitored for surface contamination and external radiation levels within three hours after receipt if received during working hours or within 18 hours if received after working hours, in accordance with the requirements of WAC 402-24-125. All shipments of liquids greater than exempt quantities will be tested for leakage. The department will be notified in accordance with the regulations if removable contamination exceeds 0.01 uCi/100 cm or if external radiation levels exceed 200 mR/hr at the package surface or 10 mR/hr at 3 feet (or 1 m).

2. For all packages, the following additional procedures for opening packages will be carried out:

   a. Put on gloves to prevent hand contamination.

   b. Visually inspect package for any sign of damage (e.g., wetness, crushed). If damage is noted, stop procedure and notify Radiation Safety Officer.

   c. Measure exposure rate at 3 feet (or 1 m) from package surface and record. If reading is greater than 10 mR/hr, stop procedure and notify Radiation Safety Officer.

   d. Measure surface exposure rate and record. If reading is greater than 200 mR/hr, stop procedure and notify Radiation Safety Officer.

   e. Open the package with the following precautionary steps:

      (1) Open the outer package (following manufacturer's directions if supplied) and remove packing slip.

      (2) Open inner package and verify that contents agree with those on packing slip. Compare requisition,* packing slip, and label on bottle.

      (3) Check integrity of final source container (i.e., inspect for breakage of seals or vials, loss of liquid, and discoloration of packaging material).

      (4) Check also that shipment does not exceed possession limits.

---

* In the case of special orders, also compare with authorized user's written request.

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f. Wipe external surface of final source container and remove wipe to low background area. Assay the wipe and record amount of removable radioactivity (e.g., uCi/100 cm , etc.). Check wipes with a thin end-window G-M survey meter, and take precautions against the spread of contamination as necessary.

g. Monitor the packing material and packages for contamination before discarding.

  (1) If contaminated, treat as radioactive waste.

  (2) If not contaminated, obliterate radiation labels before discarding in regular trash.

3. Maintain records of the results of checking each package, using "Radioactive Shipment Receipt Record" (see next page) or a form containing the same information.

Approved by__________________________________Date______________________

*

TYPE A PACKAGE QUANTITY LIMITS FOR SELECTED RADIONUCLIDES
(ADDITIONAL RADIONUCLIDES ARE LISTED IN SECTION 173.435 49.CFR)

| SYMBOL OF RADIONUCLIDE | ELEMENT AND ATOMIC NUMBER | A (Ci) (Special Form) | A (Ci) (Normal Form) |
|---|---|---|---|
| 14 | Carbon (6) | 1000 | 60 |
| 137 | Cesium (55) | 30 | 10 |
| 99 | Molybendenum (42) | 100 | 20 |
| 235 | Uranium (92) | 100 | 0.2 |
| 226 | Radium (88) | 10 | 0.05 |
| 201 | Lead (82) | 20 | 20 |

EXAMPLE

## RADIOACTIVE SHIPMENT RECEIPT REPORT

1. P.O. No: ______________ Survey Date ______________ Time ______________

Surveyor ______________________________

2. CONDITION OF PACKAGE:

O.K. Punctured Wet Crushed

(Other) ______________________________

3. RADIATION UNITS OF LABEL: ______________ (mR/hr)

4. MEASURED RADIATION LEVELS:

a. 3 feet or 1 meter from surface ______________ mR/hr

b. Package surface ______________ mR/hr

5. DO PACKING SLIP AND VIAL CONTENTS AGREE?

a. Radionuclide yes no, difference ______________

b. Amount yes no, difference ______________

c. Chem Form yes no, difference ______________

6. WIPE RESULTS FROM:

a. Outer ______________ CPM = ______________ DPM

eff = ( )

b. Final source container ______________ CPM = ______________ DPM

eff = ( )

7. SURVEY RESULTS OF PACKING MATERIAL AND CARTONS ______________ mR/hr, CPM

8. DISPOSITION OF PACKAGE AFTER INSPECTION ______________________________

9. IF DEPARTMENT/CARRIER NOTIFICATION REQUIRED, GIVE TIME, DATE, AND PERSONS NOTIFIED.

______________________________ Signature

______________________________ Date

## APPENDIX C

## Sample Incinerator Applications

Sample application is based on the N.R.C. guideline dated January 26, 1983. In addition, the sample application borrows from the applications used in Texas and California, and information derived from the Conference of Radiation Control Program Directors, Inc. report dated April 1, 1982.

It is assumed that the burden of proof rests upon the applicant in that the methods, calculations and references utilized in determining effluent concentrations and exposures to controlled and uncontrolled areas be demonstrated in the application process.

### INCINERATOR CHARACTERISTICS

Include manufacturor and model number. Describe the type of incinerator and stack specifications. Describe the system geometrics relevant to the determination of flue velocity, volume and temperature in addition to plume dynamics. Provide a description including sketches and measurements of the facility and adjacent controlled and uncontrolled areas. Describe the proximity of the incinerator to any air intake ducts. Identify the buildings in the area as to use, ownership and location.

### ISOTOPES

State which isotopes and the maximum activity of each isotope which is to be incinerated. Submit calculations to show that the gaseous effluents from the incinerator stack does not exceed the limit specified for air in Appendix B, Table II, 10 CFR Part 20 when averaged over a 24 hour period. For more than one isotope follow the "sum of the ratios" method described in the "note" at the end of Appendix B, 10 CFR Part 20. Describe any material to be incinerated with the isotopes such as debris, containers or lab animals. Describe the suitability of such materials to incinerations.

### PROCEDURES

State the number of burns to be performed in any one week and the maximum numbers of burns per year. Describe the procedures for receiving, storing, and related preparations of the material to be incinerated. Describe the method for charging of the incinerator and for ash removal.

## ASH

Describe the method used to estimate the concentration of radioactive material remaining in the ash residue assuming that all radioactive material remains in the ash. Describe the packaging, labeling, placarding, transportation and ultimate disposition of the ash.

## TRAINING

Describe the training and experience possessed by the individuals operating the incinerator and those individuals responsible for the monitoring of the effluents and facility.

## PERSONNEL PROTECTION

Submit the procedures for minimizing exposure to personnel during all phases of the operation. Describe procedures, protective apparel and monitoring. Submit copies of emergency and decontamination procedures. Describe the methods and frequency of facility contamination and exposure surveys.

## RELATED COMPLIANCE

Submit evidence that State and local air quality standards and requirements will be met in addition to compliance with EPA standards for incinerator emissions. Include any permits needed to meet nonradiogical hazards.

## APPLICATION FOR THE INCINERATION OF RADIOACTIVE WASTE

### General Items

1. (a) NAME AND STREET ADDRESS OF APPLICANT

(b) LOCATION OF THE INCINERATOR FACILITY

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2. OPERATIONS SUPERVISOR. (Name and title of individual(s) who will directly supervise the incineration of materials which are radioactive, or contain radioactive materials.)

3. RADIATION SAFETY OFFICER. (Name of person designated as radiation safety officer if other than the operations supervisor).

4. TRAINING OF OPERATIONS SUPERVISOR.
(Use separate sheet. Address each of the following topics listing the source and duration of training. Include both formal training and training gained through previous job and professional experience).

   a. Principles and practices of radiation protection.

   b. Radiation detection, measurement and monitoring.

   c. Biological effects of radiation.

   d. Incinerator operations.

   e. Facility decontamination.

5. OPERATIONS SUPERVISOR(S) EXPERIENCE.
(Summarize experience related to the handling, monitoring and/or incineration of radioactive waste. Address each of the following items).

   a. Isotopes.

   b. Maximum quantities and uses of each of the above.

   c. Incinerator experience.

   d. Source and duration of experience in a and c above.

6. INVENTORY OF RADIATION DETECTION EQUIPMENT.

a. Survey and Area Monitoring

| Type | Use | Window Thickness | Number Available | Radiation Detected | Range | Sensitivity |
|---|---|---|---|---|---|---|

b. Personnel Monitoring
(Include film badges)

| Type | Use | Number Available | Radiation Detected | Range | Sensitivity |
|---|---|---|---|---|---|

7. DESCRIBE THE METHOD, FREQUENCY AND STANDARDS USED IN CALIBRATION OF THE INSTRUMENTS LISTED IN 6(a) and (b).

DESCRIBE THE METHODS AND FREQUENCY OF PERSONNEL BIOASSAY PROCEDURES

The following is meant as a guide to expedite the licensing procedure. Keep answers concise. Questions not applicable to the licensee should be indicated as N.A.)

8. Describe the physical form of the material to be incinerated (gas, liquid, solid or slurry).

9. List the isotopes with mass numbers to be incinerated.

10. List the maximum number of curies of each isotope to be incinerated per year.

11. List the maximum number of each isotope to be incinerated per incinerator charge.

12. Describe the composition of tagging agents or other chemical constituents of the isotope.

13. Describe the nature of non-radioactive debris which will be incinerated with the isotopes.

14. Describe how characteristics such as melting and vaporization points, explosive potential, flammability and oxidation by products have been utilized in determining the suitability of incineration as a disposal/volume reduction method.

15. Demonstrate methods for determining isotope concentrations in ash and stack gas.

## STACK SPECIFICATIONS

16. Stack height. (meters)

17. Outlet diameter. (meters or cm.)

18. Outlet temperature. (centigrade)

19. Flue gas velocity. (meters/sec.)

## STACK EMISSION TREATMENT

(Complete only if emission control mechanisms are used.)

20. Describe the methods to filter, scrub, precipitate or quench stack emissions.

21. Describe the maintenance specifications for treatment systems.

22. Describe the methods of disposing filtrates or/and quenching water.

## (PACKAGING AND HANDLING)

23. Describe the packaging or containment of LLW as received for incineration.

24. Describe the storage of LLW prior to incineration.

25. Describe the reduction of LLW to charge batches.

26. Describe the method of incinerator charging.

27. Describe the methods of contamination control for dust and spillage.

28. Describe the methods and frequency of ash removal.

## PROCEDURES

29. Provide copies of procedures, as applicable, for the following:

    a. Incinerator Decontamination

    b. Personnel Decontamination

    c. Emergency Procedures

    d. Personnel Monitoring

    e. Facility Survey

    f. Personnel Training

    g. Evidence that all government agencies having jurisdiction have been notified of radioactive waste incineration plans and have no objection.

    h. A.L.A.R.A. Guides

## ASH AND EFFLUENTS

30. Describe the methods for monitoring isotope concentration in ash and flue gas.

31. Describe the methods of packaging and transporting ash.

MISCELLANEOUS

Demonstrate calculations used to estimate gaseous effluent from the incineration stack.

(If more than one isotope is involved, the calculations must follow the "sum of ratios" method in the "Note" at the end of Appendix B, 10 Part 20.)

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U.S. NUCLEAR REGULATORY COMMISSION

# BIBLIOGRAPHIC DATA SHEET

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This guidance was written to assist Agreement States and applicants addressing low-level waste processing as regulators or as licensees. The Low-Level Radioactive Waste Management Committee (E-5) of the Conference of Radiation Control Program Directors prepared this guidance document after evaluating current waste compaction and incineration practices with consideration of present applicable regulatory requirements for licensing. Incineration and compaction processes to reduce low-level radioactive waste volume have been licensed by Agreement States and by the U.S. Nuclear Regulatory Commission for over 20 years. Incineration volume reduction factors in the range from 10 to 100 have been achieved and compaction can reduce the waste volume by factors from 2 to 10 or more with accompanying reduction in the costs for waste disposal. In preparation of this guidance, the focus has been on keeping radiation exposure "as low as reasonably achievable." Compaction and incineration in particular to produce a more stable waste form with enhanced performance characteristics after disposal is a positive step toward that end. This document does not specifically address incinerator or compactor installations at nuclear power plants.

14. DOCUMENT ANALYSIS – a. KEYWORDS/DESCRIPTORS
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